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Investor Sentiment, Financial Report Quality and Stock Price Crash Risk: Role of Short-Sales Constraints

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ABSTRACT: We use firm-year observations of Chinese firms between 2003 and 2013 and empirically investigate the association between investor sentiment and stock crash risk with respect to short-sales constraint conditions. In addition, we also evaluate the incremental effect of financial reporting quality on this association and the existence of such an association under market conditions. We find that investor sentiment is positively associated with future stock price crash risk and poorer financial report quality and short-sale constraint will strengthen this association. In consideration of the firm-level fundamental information in stock prices and different market states, we find that lower fundamental information in stock price and bull market state will strengthen the positive association between investor sentiment and future stock price crash risk. Our findings are robust with several robustness checks.

KEY WORDS: crash risk, financial report quality, investor sentiment, short-sales constraints

The asymmetry of volatility in stock returns (large price movements are more likely to be crashes rather than increases) not only may cost the investors their wealth, but also does harm to the stability and development of capital markets. Its striking characters are that stock markets crash in the absence of negative information and contagiously across the entire class of stocks (Hong and Stein 2003).

Investigations on stock price crashes rise in the 1980s. The initial analyses are developed on the framework of rational models with complete information aggregation, and the workhorse is volatility feedback models, which explain the asymmetric changes in stock prices (Campbell and Hentschel 1992). But these models cannot fit the distinct facts of the crashes such as the stock prices dropping systematically without pieces of information. Then, further studies focus on three aspects: the asymmetric information, market fraction, and differences of investors' opinions, indicated by the rational models with incomplete information aggregation and behavioral finance. Rational models with incomplete information aggregation implies that crash risk is the result of intensive release of private information by insiders (Romer 1993; Cao, Coval, and Hirshlerfer 2002) and the push work by the outsiders (Barlevy and Veronesi 2003). Marin and Olivier (2008) demonstrate that inside trade volume, which is lagged from two months to twelve months, has a significantly positive relation with stock crash risk, which is consistent with the conclusions of Romer (1993) and Cao, Coval, and Hirshlerfer (2002), they show that inside traders release large amounts of news at one time, which increases the crash risk. Grech and Mazur (2004) document that information efficiency and the degree of asymmetry affects the crash risk. They show that lower information efficiency means a higher crash risk. Hutton, Marcus, and Tehranian (2009) uses accruals to measure the transparency of financial statement and find that the transparency is significantly negative with crash risk. Atilgan and Demirtas (2013) investigate the relation between downside risk and expected returns on the aggregate stock market in an international context and find that, for emerging markets, fixed effects panel data regressions provide evidence for a significantly positive relationship between monthly expected market returns and downside risk.

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Behavioral finance explains the crash risk from two aspects: investor sentiment and differences of investors' opinions. Case and Shiller (1989) compares the sentiment of investors and economic fundamentals before the crash in 1987 with those after the stock crash. His finding is that the factor accounting for the crash is investor sentiment rather than the economic fundamentals. The economic fundamental did not change and the sentiment dropped sharply, which was overoptimistic before the stock crash and became pessimistic after the crash. Hong and Stein (2003) develop a new model to grip with the characteristics, which were not explained by volatility feedback models. The new model has two assumptions, differences of investors' opinions due to overconfidence and short-sales constraints. Griffin, Nardari, and Stulz (2007) also supports their theory. They declare six months lagged turnovers have significant positive coefficients of the regression with the negative skewness of stock returns. Brooks and Katsaris (2005) divide the market states into three states: slowing up, skyrocketing, and bubble burst, and then build a three state model of transformation. They find that excess trade gets a significantly positive relation with the bubble burst risk.

This article develops the theory on the framework of behavioral finance and put another two factors, information efficiency and short-sales constraint of rational models with incomplete information aggregation, into the analysis. We study how the differences of sentiment caused by information efficiency constraints affect the potential of a stock crash in China. We conclude that the core variable of the behavioral finance is investor sentiment, which comes from investors' expectations of asset prices. This article treats the sentiment as an endogenous variable and explores a new transmission mechanism in which the information efficiency affects the expectations and then influences the sentiment and stock price. The information efficiency can be interpreted as the quality of financial reports or the fundamental information of companies in stock price. According to Hong and Stein (2003), with short-sale constraint, the stock price reveals the expectations of optimistic investors rather than pessimistic investors. Thus the bearish private information gets hidden and accumulates. When the markets go down, such bearish information pours into the market and raises the crash risk. Without short-sale constraint, investors would make security financing trades to release the bearish information, and then different types of investors learn about the negative information. Stock prices go down slowly, predicting the lower crash risk. So the presence of constraints would affect the actual influences on the stock price from sentiment. This article develops a theoretical model to demonstrate the negative relation between sentiment and stock return with the short-sale constraint, and then in the empirical analysis we set the crash risk variables following Chen, Hong, and Stein (2001) and Kim et al. (2011a, 2011b). As the theoretical model implied, investor sentiment is positively associated with future stock price crash risk and poorer financial report quality and short-sale constraint will strengthen this association. Lower fundamental information in stock price and bull market state will also strengthen the positive association between investor sentiment and future stock price crash risk.

The contribution of this article is our interact combination of rational models with incomplete information aggregation and behavioral finance. We explore a new transmission mechanism, indicating the inherent relation between incomplete information and investor sentiment in explaining the stock crash.

Model Design and Hypotheses

Delong et al. (1990) present a model to study how the noise traders affect the stock return in the market, which contains rational investors and noise investors, and demonstrate that the wrong beliefs of noise traders actually affect the stock return. The idea gets supported by the following empirical work. The assumptions in our model are close to those in the model of Delong et al. (1990).

1. The market includes two different assets with the same dividends r. One is safe assets, and the other is risk asset u. The price of s is standardized as 1. The price of risk asset is supposed to be p_t, and the total supply of risk asset is 1.

2. The market contains two kinds of investors, noise traders, and rational investors. Noise traders trade according to their expectations. At the time t, the misjudge on the price is quantized as the deviation to the expected price of asset u in the future ρ_t. It is an independent and distributed normal random variable,$\rho_t \sim N\left(\rho_t^*, \sigma_{\rho_t}^2\right)$. ρ_t^* is the mean of expected price of risk asset, which imply the degree of the sentiment of noisy traders. The rational investors have sophisticated expectations about the dividends and distribution of risky assets. Their demand of risk assets is dependent on the arbitrage opportunity between the spot price and the inherent value. Rational investors exploit the noise traders' mispricing by taking the adverse strategies. The proportion of noise traders is β, and the rational investors are weighted as 1–β. Over the life, the two types of investors have two life periods: young age t and old age t + 1. They choose the portfolios when they are young, and would sell the risk assets at the price p_{t+1} and then consume the wealth.
3. The return of risk assets is distributed as normal distribution and the agents' utility function is U (w), where w is the value of traders' wealth. The traders maximize the expected utility,$E(U) = \overline{w} - \gamma\sigma_w^2$, where $\overline{w}$ is expected final wealth, γ is the coefficient of absolute risk aversion, andσ_w^2 is the variance of wealth.

The expected utility of rational traders is:

$$\begin{aligned} E(U_a) &= \overline{w}_a - \gamma\sigma_{w_a}^2 \\ &= s(L_a) + \lambda_t^a[r + E_t(p_{t+1}) - p_t(1+r)] - \gamma\left(\lambda_t^a\right)^2\left[E_t\left(\sigma_{p_{t+1}}^2\right)\right], \end{aligned} \tag{1}$$

where $s(L_a)$ is the function of labor income of rational traders, $\sigma_{p_{t+1}}^2 = [p_{t+1} - E_t(p_{t+1})]^2$ is the variance of p_{t+1} of risk assets at time t, and λ_t^a represent the amounts of risky assets held by rational traders.

The expected utility of noise traders is:

$$\begin{aligned} E(U_n) &= \overline{w}_n - \gamma\sigma_{w_n}^2 \\ &= s(L_n) + \lambda_t^n[r + E_t(p_{t+1}) - p_t(1+r)] - \gamma\left(\lambda_t^n\right)^2\left[E_t\left(\sigma_{p_{t+1}}^2\right)\right] + \lambda_t^n(\rho_t), \end{aligned} \tag{2}$$

where $s(L_n)$ is the function of labor income of noise traders, λ_t^n represent the amounts of risky assets held by noise traders, and ρ_t is the deviation to expected price of u at time of t and distributed as a normal random variable.

The total supply of risk assets is 1:

$$(1-\beta)\lambda_t^a + \beta\lambda_t^n = 1 \tag{3}$$

The equilibrium price of risk assets comes from the maximization of the utilities of rational and noise traders:

$$\max : s(L_a) + \lambda_t^a[r + E_t(p_{t+1}) - p_t(1+r)] - \gamma\left(\lambda_t^a\right)^2\left[E_t\left(\sigma_{p_{t+1}}^2\right)\right]$$

$$\max : s(L_n) + \lambda_t^n[r + E_t(p_{t+1}) - p_t(1+r)] - \gamma\left(\lambda_t^n\right)^2\left[E_t\left(\sigma_{p_{t+1}}^2\right)\right] + \lambda_t^n(\rho_t)$$

$$s.t. : (1-\beta)\lambda_t^a + \beta\lambda_t^n = 1 \tag{4}$$

Maximize the Equation (4):

$$\lambda_t^a = \frac{r + E_t(p_{t+1}) - (1+r)p_t}{2\gamma\left[E_t\left(\sigma^2_{p_{t+1}}\right)\right]} \tag{5}$$

$$\lambda_t^n = \frac{r + E_t(p_{t+1}) - (1+r)p_t}{2\gamma\left[E_t\left(\sigma^2_{p_{t+1}}\right)\right]} + \frac{\rho_t}{2\gamma\left[E_t\left(\sigma^2_{p_{t+1}}\right)\right]} \tag{6}$$

Put Equation (5) and (6) into Equation (4):

$$p_t = \frac{1}{1+r}\left[r + E_t(p_{t+1}) - 2\gamma E_t\left(\sigma^2_{p_{t+1}}\right) + \beta\rho_t\right] \tag{7}$$

Equation (7) calculated recursively:

$$p_t = 1 + \frac{\beta\left(\rho_t - \rho_t^*\right)}{1+r} + \frac{\beta\rho_t^*}{r} - \frac{2\gamma}{r}\left[E_t\left(\sigma^2_{p_{t+1}}\right)\right] \tag{8}$$

The volatility of stock price is independent on the noise traders' expectations of the volatility of stock price:

$$E_t\left(\sigma^2_{p_{t+1}}\right) = \sigma^2_{p_{t+1}} = \frac{\beta^2\sigma^2_{\rho_t}}{(1+r)^2} \tag{9}$$

We can get:

$$p_t = 1 + \frac{\beta\left(\rho_t - \rho_t^*\right)}{1+r} + \frac{\beta\rho_t^*}{r} - \frac{2\gamma\beta^2\sigma^2_{\rho_t}}{r(1+r)^2} \tag{10}$$

The return of risk assets:

$$return_{t+1} = r + p_{t+1} - p_t(1+r) = -\frac{2+r}{1+r}\beta\rho_t^* + \frac{\beta\rho_{t+1} + (\beta+r)p_t}{1+r} \tag{11}$$

The expected return of risk assets:

$$E_t(return_{t+1}) = -\frac{2+r}{1+r}\beta\rho_t^* + \frac{(\beta+r)p_t}{1+r} \tag{12}$$

Then:

$$\partial E_t(return_{t+1})/\partial\rho_t^* = -\frac{2+r}{1+r}\beta < 0 \tag{13}$$

Equation (13) imply that a higher traders' sentiment ρ_t^* interpret a lower return of risk assets.

Compared to the capital markets of developed countries, the proportion of institution investors is smaller and individual investors are crucial for the formation of stock prices. If the investors' sentiment is higher that means they hold more optimistic attitudes to the stock return and they act over-confidently in the trades. There are significant contrarian effects in the Chinese stock market. Liu and Pi (2007) find the significant contrarian effect and reject the momentum based on full sample data from 1994–2005 in China Shanghai and Shenzhen A share market. They conclude that risk accounts

partly for such a phenomenon. Li (2013) combines the model of Rodriguez and Sbuelz (2006) with robustness and predicts that the investors with robustness partly carry out contrarian strategies. In our model, rational investors exploit the mispricing of noise investors and carry out contrarian strategies. Based on the annual data, we find if the investors' sentiment is higher at present, the stock price have the momentum effect in short time. But in a longer period, the stock tends to have the contrarian effect because of the rational investors' carrying out adverse strategies. In a word, a higher the sentiment now implies a lower the stock return.

Chen and Zhang (2009) investigate the micro-mechanism of the crash of Chinese stock market with short-sale constraint based on the Hong and Stein (2003) heterogeneous beliefs model. They find the absence of short-sale mechanism raises the crash risk because of differences of investors' opinions and predict that the security financing would reduce the potential of stock crash. According to Hong and Stein (2003), stock price only reveals the expectations of optimistic investors rather than pessimistic investors. Then the bearish information gets hidden and accumulates, which raises the crash risk when the market goes down. With the short-sale constraint, investors would make security financing trades to release the bearish information, and then different types of investors learn to know the bearish information and stock price goes down slowly, reducing the crash risk. Therefore we develop these hypotheses:

H1: With the short-sale constrain, a higher investors' sentiment indicates a larger crash risk. If security financing is available, there is no significant relationship between sentiment and crash risk.

The listed companies produce information, and have the tendency to release information selectively to meet their own interests. To maintain the stock price, the managers tend to hide bad news. The bad news accumulates until the board cannot be burdened. Then large amounts of bad news pour into the market and the company stock crashes (Jin and Myers 2006). Hutton, Marcus, and Tehranian (2009) uses earning management to represent the transparency of financial statements, and they find the opaque of financial reports has a significantly negative relationship with crash risk. We can get that the higher the investors' sentiment, the bigger crash risk in the future. Even if the accumulated bad news gets released at present, the crash risk still becomes higher because of the short-sale constraint.

H2: With the short-sale constraint, the transparency would strengthen the positive relationship between the investor sentiment and the potential of stock crash.

Research Design

Dependent Variable: Stock Price Crash Risk NCSKEW and DUVOL

In literature, there are two kinds of measures to describe crash risk. One is negative coefficient of skewness (Chen, Hong, and Stein 2001; Kim, Li, and Zhang 2011a, 2011b). The other is binary variable CRASH, which represents whether the crash happens or not. Given the stock return follows normal distribution, $r \sim (u, \delta)$, if $r \leq u\text{-}2\delta$, CRASH equals 1. Otherwise, CRASH equals 0 (Marin and Olivier 2008; Hutton, Marcus, and Tehranian 2009). We follow the first variable measure (Chen, Hong, and Stein 2001; Kim et al. 2011a, 2011b) to interpret the potential of crash risk and develop the CRASH measure in robustness test.

Regress the Equation (14) to get residual series $\varepsilon_{i,t}$ and specific weekly return of stock i at time t is $W_{it} = \ln(1 + \varepsilon_{it})$.

$$r_{i,t} = \alpha_i + \beta_{1,i} \times r_{m,t-2} + \beta_{2,i} \times r_{m,t-1} + \beta_{3,i} \times r_{m,t} + \beta_{4,i} \times r_{m+1,t} + \beta_{5,i} \times r_{m+2,t} + \varepsilon_{i,t} \quad (14)$$

where $r_{i,t}$ and $r_{m,t}$ are correspondingly the weekly return of company i and market m. The lead and lag items of the market are employed in Equation (14) to reduce the deviation because of no synchronous trading (Dimson 1979).

Then we give the calculation of NCSKE and DUVOL.

NCSKEW comes from Equation (15):

$$NCSKEW_{i,t} = -\left(n(n-1)^{3/2}\sum W_{i,t}^3\right)/\left((n-1)(n-2)\left(\sum W_{i,t}^2\right)^{3/2}\right) \tag{15}$$

where n is the number of stock i's trading weeks. If NCSKEW is bigger, the stock has a more negative skewness and a larger crash risk.

The way we get DUVOL is as follows. We divide the companies into two categories: one contains the companies whose returns are below the period mean, "down weeks" and the other one contains the companies whose returns are above the period mean, "up weeks."

Then we calculate the standard deviation respectively, and DUVOL is a specific return standard deviation of down weeks divided by the one of up weeks:

$$DUVOL_{i,t} = \log\left\{\left[(n_u-1)\sum_{DOWN} W_{i,t}^2\right]/\left[(n_d-1)\sum_{UP} W_{i,t}^2\right]\right\} \tag{16}$$

where $n_u(n_d)$ is the number of up(down) weeks of stock i. That DUVOL is bigger means the crash risk become bigger.

Independent Variables

Investor Sentiment

Brown and Cliff (2004) show that the definition of sentiment can be interpreted as the degree of optimism or pessimism. But it is difficult to give an accurate measure and different literature chooses the specific proxy variable to represent the investor sentiment, such as turnovers (Jones and Owen 2002), IPO return (Ritter and Welch 2002), and discount rate of closed-end funds (Lee, Shleifer, and Thaler 1991). Baker and Wurgler (2006) verify the prediction accuracy of turnovers, IPO initial return, and discount rates of closed-end funds (CEFD) to revenue. Wu and Han (2007) uses the growth rate of investors' opening accounts, Open, as the proxy variable. The number of accounts in the exchanges reveal the investors' demand of securities. When the sentiment of outside investors becomes higher, they are more likely to step into the stock market, and vice versa. Because of scarcity of the IPO opportunities, there is always a high IPO initial return even if the market is not bullish. So IPO initial return is not a proper measure of investor sentiment. Another proxy variable, Ratio, means the number of listed company' going up divided by the one of listed company' melting down in correspondingly statistics interval. This article employs turnover, CEFD, Open and Ratio as the proxy variables to represent the sentiment.

We employ the variables to create a comprehensive sentiment index using the factor analysis method:

$$Sentiment_t = 0.796 * Ratio_t + 0.6735 * CEFD_t + 0.440 * Turnover_t + 0.1842 * Open_t. \tag{17}$$

Transparency of Financial Statements: ACCM

Companies are prone to adjust the accruals to control the profits, which strengthen the asymmetry between the investors and companies. We follow Hutton (2009).

Regress Equation (18) as the adjusted Jones model (Dechow, Sloan, and Sweeney 1995) implies.

$$\frac{TA_{i,t}}{Asset_{i,t-1}} = \alpha_0 \frac{1}{Asset_{i,t-1}} + \beta_1 \frac{\Delta Sales_{i,t}}{Asset_{i,t-1}} + \beta_2 \frac{PPE_{i,t}}{Asset_{i,t-1}} + \varepsilon_{i,t} \tag{18}$$

where, $Asset_{i,t-1}$ is the total asset of company at time t–1, $TA_{i,t}$ is the total Accruals at time t, equals (changes in liquid assets – changes in cash and equivalent assets) – changes in total liquid debt – changes in short-term borrowing – changes in income tax payable) – depreciation and amortization expense in the corresponding interval, $\Delta Sales_{i,t}$ is the change in sales at time t and $PPE_{i,t}$ is the investment in fixed assets at time t.

Put the coefficient of the regression of Equation (18) in Equation (19) to compute the transparency of financial statements ACCM:

$$ACCM_{i,t} = \frac{TA_{i,t}}{Asset_{i,t-1}} - \left(\hat{\alpha}_0 \frac{1}{Asset_{i,t-1}} + \hat{\beta}_1 \frac{\Delta Sales_{i,t} - \Delta Receivables_{i,t}}{Asset_{i,t-1}} + \hat{\beta}_2 \frac{PPE_{i,t}}{Asset_{i,t-1}} \right) \tag{19}$$

where $\hat{\alpha}_0$, $\hat{\beta}_1$, and $\hat{\beta}_2$ are the coefficients of regression of Equation (19), $\Delta Receivables_{i,t}$ is changes in accounts receivable at time t. A bigger ACCM implies the worse of the transparency of financial statements.

State of MARKET: MARKET

Following Lindahl-Stevens (1980) and Xu et al. (2012), we define the period where the market return exceeds the riskless return as bullish market, otherwise as bearish market. We use the fixed-deposit rate as the proxy variable to describe the riskless return. If the fixed-deposit rate changes in a year, we define the mean of different rates as the annual rate. In this way, we compute the risk premium, 2003 (3.74 percent), 2004 (−17.65 percent), 2005 (−10.58 percent), 2006 (127.91 percent), 2007 (93.45), 2008 (−69.32 percent), 2009 (77.73 percent), 2010 (−16.62 percent), 2011 (−21.2087 percent), 2012 (3.2108 percent), and 2013 (−10 percent). As the rule above indicates, we define 2003, 2006, 2007, 2009, and 2012 as a bullish market, and the rest as a bearish market. If the market is bullish, MARKET = 1. Otherwise, MARKET = 0.

Model

We use Equation (20) to test hypothesis 1:

$$CRASH_t = \alpha_0 + \alpha_1 SENTIMENT_{t-1} + \sum_{q=2}^{m} \alpha_q (ControlVariables_{t-1}) + \varepsilon_t \tag{20}$$

where $CRASH_t$ including $NCSKEW_t$ and $DUVOL_t$ represents the crash risk, and $SENTIMENT_{t-1}$ describes the investor sentiment.

Hutton, Marcus, and Tehranian (2009) predicts the leverage and company operation significantly affect the stock returns. Kim et al. (2011b) finds that over the life, the growth-type enterprise tends to be vulnerable to crash risk and the size of a company is positively associated with the potential of crash.

Based on their findings, this article employs leverage LEV_{t-1}, book to market ratio MB_{t-1}, rate of return on net assets ROA_{t-1}, scale of companies $SIZE_{t-1}$, nature of companies $NATURE_{t-1}$, the proportion of institutional investors' holding $Fund\_hold_{t-1}$, the proportion of senior managers' holding $Executive\_hold_{t-1}$, ownership concentration $Ownership_{t-1}$, Tobin's q Q_{t-1}, and industry labels Industry Dummy as control variables.

We use the Equation (21) to verify how the quality of financial statements affects the relation between sentiment and crash risk.

$$CRASH_t = \beta_0 + \beta_1 ACCM_{t-1} + \beta_2 ACCM_{t-1} * SENTIMENT_{t-1} + \beta_3 ACCM_{t-1} + \sum_{q=3}^{m} \alpha_q (ControlVariable_{t-1}) + \varepsilon_t \quad (21)$$

where ACCM $_{t-1}$ is the quality of financial statements and other variables are set as those in Equation (20).

Empirical Results

Sample and Descriptive Statistics

The data of listed companies from 2003–13 in China Shanghai and Shenzhen A share market are obtained from the databases CASMAR and WIND, the quality data of company information disclosure in robustness tests comes from the regulatory disclosure offered by Shenzhen Stock Exchange; and the data of newly increased openings in stock accounts every year comes from China Securities Depository and Clearing Corporation Limited. We follow the procedure developed by Jin and Myers (2006) to set the variable to capture the crash risk in the absence of financial companies and the companies whose trade weeks is less than thirty. The remaining sample includes 9,179 firms.

Table 1 presents descriptive statistics of the variables included in this article. Because the corresponding standard deviations are 0.837 and 0.410, the two measures of crash risk have great differences, indicating that we can measure the crash risk in two different views. The mean of variable SYNCH is 0.454, implying that the stock prices go up and down simultaneously across the stock markets in China and the private information is not quite revealed in stock prices. In the trade institution, the number of companies can be involved in security financing is 713, accounting for 7.77 percent of the available sample. The number of bull years is five and the bear years is six.

Investor Sentiment and Crash Risk

The regression results of crash risk on investor sentiment are shown in Table 2, where $NCSKEW_t$ and $DUVOL_t$ are two distinct measures. The columns (1) and (3) show that the coefficients of the investor sentiment $SENTIMENT_{t-1}$ are correspondingly 0.0012 and 0.0004, which are statistically significant at the 1 percent level. The results above indicate that a higher investor sentiment at time t–1 is associated with a higher crash risk at time t. To eliminate the potential influence caused by the nature of the company, we employ a new variable to interpret the nature of the company in the regression, which improves the goodness of fit significantly. The coefficients of the investor sentiment $SENTIMENT_{t-1}$ are 0.0027 and 0.0008 respectively, which are statistically significant at the 1 percent level. This result shows that the positive relation between investor sentiment and crash risk is not affected by the nature of the company. The aforementioned results demonstrate hypothesis 1.

Investor Sentiment and Crash Risk: Financial Report Quality and Short-Sale Constraints

The investor expectations toward stock price and investment decision are affected by the external environment. This article goes on further studies in the presence of the exotic conditions including the financial report quality, the private information involved in the stock price, the trade institution, and the market state. We investigate how the exotic conditions affect the relation between the investor sentiment and the crash risk. Table 3 presents the following empirical results. (1) The cross terms $ACCM_{t-1}$*$SENTIMENT_{t-1}$ of the financial report quality and the investor sentiment are 0.0008 and 0.0002, respectively. The coefficients are statistically significant at the 5 percent level, which indicates the more asymmetric the information would strengthen the positive relation between investor sentiment and crash risk. The mechanism is that the information raises the investors' blindness to stock price, and then blind optimism leads to a higher crash risk. (2) The cross terms of the private information about the company

Table 1. Descriptive statistics

Variable	N	Mean	Std	5%	25%	Median	75%	95%
Dependent Variable								
Crash Risk								
$NCSKEW_t$	9179	−0.181	0.837	−1.842	−0.458	−0.044	0.088	1.288
$DUVOL_t$	9179	−0.106	0.410	−0.770	−0.369	−0.108	0.155	0.568
$CRASH_t$	9179	0.366	0.482	0	0	0	1	1
Independent Variable								
Investor Sentiment								
$SENTIMENT_{t-1}$	9179	25.127	29.891	−7.732	2.334	17.011	39.586	85.110
Report Quality								
$ACCM_{t-1}$	9179	0.091	1.122	−0.575	−0.105	0.074	0.281	0.921
$INFO_{t-1}$	3071	2.186	0.654	1	2	2	3	3
Synchronicity								
$SYNCH_{t-1}$	9179	0.454	0.680	−0.537	0.028	0.403	0.821	0.924
$IDIOSYNCRATIC_{t-1}$	9179	1.430	0.428	0.796	1.125	1.395	1.702	2.178
Trade Institution								
CONSTRAINT = 1	713							
CONSTRAINT = 0	8466							
Market State								
BULL MARKET	5							
BEAR MARKET	6							
Control Variable								
LEV_{t-1}	9179	0.078	0.111	0	0.001	0.030	0.114	0.310
MB_{t-1}	9179	0.623	0.268	0.205	0.418	0.610	0.813	1.079
RET_{t-1}	9179	0.002	0.016	−0.014	−0.006	−0.001	0.007	0.025
ROA_{t-1}	9179	0.048	0.251	−0.047	0.030	0.053	0.082	0.154
$SIGMA_{t-1}$	9179	0.061	0.055	0.033	0.044	0.055	0.070	0.100
$SIZE_{t-1}$	9179	14.310	1.2515	12.451	13.391	14.229	15.087	16.523
$NATURE_{t-1}$	9179	0.443	0.497	0	0	0	1	1
$HOLD_{t-1}$	9179	3.834	7.190	0	0	0.429	4.276	19.698

and the investor sentiment have coefficients of 0.0007 and 0.0002, which are positive significantly on the 1 percent and 5 percent level. Such results can be interpreted as the less the amount of private information revealed in stock price, the more significant the relationship between investor sentiment and crash risk. This finding is in accord with the aforementioned finding, which indicates that the more the amount of private information revealed in stock price, the less financial report quality is involved in stock prices. (3) The coefficients of the cross terms of short-sale constraints and investor sentiment are −0.0026 and −0.0007 respectively, which are both significant at the 5 percent level. Such results reveal that the security financing reduces the positive relationship between the investor sentiment and the crash risk with a high significance, which is consistent with the study carried out by Hong and Stein (2003). For example, in the absence of short-sale constraints, the bear information from some investors comes into the stock price readily, and other investors recognize such information and then adopt their expectations about the stock returns, which reduces the crash risk. (4) The cross terms $MARKET_{t-1}$*$SENTIMENT_{t-1}$ of the market state and the investor sentiment have coefficients of −0.0007 and −0.0014, which are significantly negative on the 5 percent level. We conclude from the external risk that the market is a bull market, which would strengthen the positive relationship between the investor sentiment and the crash risk. In bull markets, the investors share more optimistic sentiment (Xu, Yu, and Yi 2013), which induces a higher crash risk. Such conclusion is in keeping with the significant contrarian effect in medium- and long-term in China stock markets found by (Liu and Pi 2007).

Table 2. Investor sentiment and crash risk

	$NCSKEW_t$		$DUVOL_t$	
	(1)	(2)	(3)	(4)
$SENTIMENT_{t-1}$	0.0012***	0.0027***	0.0004***	0.0008***
	(4.41)	(7.19)	(2.93)	(4.72)
LEV_{t-1}		−0.1214		−0.0281
		(−1.35)		(−0.68)
MB_{t-1}		0.2520***		0.1994***
		(6.28)		(10.87)
RET_{t-1}		−8.7244***		−3.5766***
		(−10.41)		(−9.33)
ROA_{t-1}		−0.0483		0.0234
		(−1.31)		(1.39)
$SIGMA_{t-1}$		2.0729***		0.7853***
		(9.62)		(7.97)
$SIZE_{t-1}$		0.0005		0.0367***
		(0.06)		(9.15)
$NATURE_{t-1}$		0.0006		−0.0336***
		(0.03)		(−3.89)
$HOLD_{t-1}$		−0.0007		−0.0040***
		(−0.49)		(−6.38)
_CONS	0.2854***	0.0158	0.0743**	−0.5778***
	(4.31)	(0.11)	(2.29)	(−8.58)
IND_DUM	YES	YES	YES	YES
OBS	9179	9179	9179	9179
ADJ_R2	0.0043	0.0249	0.0063	0.0448

Notes: Here *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels respectively.

Robustness Tests

Based on four aspects of the information disclosure of the companies, authenticity, completeness, legitimacy and equality, Shenzhen stock exchange ranks and divides the companies into four camps, A, B, C, and D, in order from 2001. A represents the highest quality of information disclosure. The higher quality of a company's disclosure indicates the lesser financial report quality faced by investors. This article converts the quality of disclosure to numerical scores as follows: A takes on a value of 4; B 3; C 2; and D 1. The bigger number is associated with a higher financial report quality. We use variable INFO as financial report quality. The idiosyncratic volatility is stock volatility minus market volatility, which is attributed to private information in stock price. Ang et al. (2006) finds the idiosyncratic volatility has a negative relationship with the stock return. This article employs the idiosyncratic volatility as proxy variable to capture the private information contained in stock prices.

We calculate the idiosyncratic volatility as follows:

Regress the Fama-French three factors model:

$$R_{i,t} - R_{M,t} = \alpha_{i,t} + \beta_{i,t}(R_{M,t} - R_{f,t}) + s_{i,t}SMB_{i,t} + h_{i,t}HML_{i,t} + \varepsilon_{i,t} \tag{24}$$

where, $R_{i,t}$ is the weekly return of stocks, $R_{m,t}$ is the weekly return of stocks, $R_{f,t}$ is the riskless return, $SMB_{i,t}$ is the sale, and $HML_{i,t}$ is the book-to-market ratio.

Table 3. Investor sentiment and crash risk

	$NCSKEW_t$				$DUVOL_t$			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$SENTIMENT_{t-1}$	0.0026***	0.0044***	0.0025***	0.0022***	0.0008***	0.0013***	0.0007***	0.0008***
	(6.90)	(7.97)	(6.57)	(5.59)	(4.55)	(5.09)	(4.35)	(4.48)
$ACCM_{t-1}$*$SENTIMENT_{t-1}$	0.0008**				0.0002**			
	(2.42)				(2.23)			
$ACCM_{t-1}$	−0.0004				0.0045			
	(−0.03)				(0.80)			
$SYNCH_{t-1}$*$SENTIMENT_{t-1}$		0.0007***				0.0002**		
		(3.31)				(2.36)		
$SYNCH_{t-1}$		0.0585***				0.0123**		
		(6.52)				(2.98)		
$CONSTRAINT_{t-1}$*$SENTIMENT_{t-1}$			−0.0026**				−0.0007**	
			(−2.32)				(−2.79)	
$CONSTRAINT_{t-1}$			−0.1366**				−0.0490*	
			(−2.48)				(−1.94)	
$MARKET_{t-1}$*$SENTIMENT_{t-1}$				−0.0007**				−0.0014**
				(−2.73)				(−2.92)
$MARKET_{t-1}$				0.3095***				0.1141***
				(9.65)				(7.75)
LEV_{t-1}	−0.1224	−0.1454	−0.1249	−0.0770	−0.0282	−0.0316	−0.0279	−0.0154
	(−1.36)	(−1.62)	(−1.39)	(−0.86)	(−0.69)	(−0.77)	(−0.68)	(−0.38)
MB_{t-1}	0.2521***	0.2953***	0.2619***	0.1331***	0.1997***	0.2060***	0.2044***	0.1624***
	(6.28)	(7.26)	(6.50)	(3.23)	(10.88)	(11.05)	(11.09)	(8.59)
RET_{t-1}	−8.7029***	−9.2570***	−8.7897***	−6.3500***	−3.5623***	−3.7033***	−3.6514***	−3.0772***
	(−10.39)	(−11.01)	(−10.48)	(−7.20)	(−9.30)	(−9.61)	(−9.52)	(−7.60)
ROA_{t-1}	−0.0491	−0.0378	−0.0508	−0.0423	0.0230	0.0247	0.0222	0.0249
	(−1.33)	(−1.03)	(−1.38)	(−1.16)	(1.36)	(1.47)	(1.32)	(1.49)
$SIGMA_{t-1}$	2.0641***	2.1741***	2.0798***	1.3987***	0.7810***	0.8067***	0.7956***	0.6274***
	(9.58)	(10.08)	(9.65)	(6.17)	(7.92)	(8.16)	(8.07)	(6.03)
$SIZE_{t-1}$	0.0008	0.0089	0.0113	0.0347***	0.0368***	0.0381***	0.0431***	0.0470***
	(0.09)	(1.00)	(1.15)	(3.76)	(9.18)	(9.40)	(9.59)	(11.12)

(*Continued*)

Table 3. Investor sentiment and crash risk (Continued)

	$NCSKEW_t$				$DUVOL_t$			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$NATURE_{t-1}$	0.0009	0.0096	−0.0013	−0.0212	−0.0334***	−0.0326***	−0.0336***	−0.0397***
	(0.05)	(0.51)	(−0.07)	(−1.12)	(−3.87)	(−3.75)	(−3.88)	(−4.58)
$HOLD_{t-1}$	−0.0008	−0.0013	−0.0008	−0.0047***	−0.0041***	−0.0042***	−0.0041***	−0.0052***
	(−0.56)	(−0.93)	(−0.56)	(−3.29)	(−6.45)	(−6.58)	(−6.48)	(−8.07)
_CONS	0.01846	−0.2748*	−0.1302	−0.3935**	−0.5777***	−0.6287***	−0.6647***	−0.7013***
	(0.13)	(−1.79)	(−0.82)	(−2.61)	(−8.58)	(−8.93)	(−9.15)	(−10.15)
IND_DUM	YES	YES	YES	YES	YES	YES	YES	YES
OBS	9179	9179	9179	9179	9179	9179	9179	9179
ADJ_R2	0.0261	0.0293	0.0254	0.0382	0.0455	0.0421	0.0459	0.0512

Notes: Here *, **, and *** indicate statistical significance at the 10 percent, 5 percent, and 1 percent levels respectively.

Then we get the idiosyncratic volatility:

$$IDIOSYNCRATIC_{i,t} = (R_{i,t} - R_{M,t}) - \hat{\alpha}_{i,t} + \hat{\beta}_{i,t}(R_{M,t} - R_{f,t}) + \hat{s}_{i,t}SMB_{i,t} + \hat{h}_{i,t}HML_{i,t} \quad (25)$$

where $\hat{\alpha}_{i,t}$, $\hat{\beta}_{i,t}$, $\hat{s}_{i,t}$ and $\hat{h}_{i,t}$ are the estimates of coefficients in Equation (24).

The sample included in security financing in Table 4 is regressed in the general regression. And in China the security financing has been carried out since 2009. To unify the sample interval, we study the sample in and since 2009 to find out how the security financing affects the relationship between investor sentiment and crash risk. In particular, some stocks exit from the security financing sample, which offers us an opportunity to compare the relationship between investor sentiment and crash risk of the same stock with and in the absence of security financing.

One of the robustness tests shown in Table 4. $INFO_{t-1}$ is the quality of listed company information disclosure in the Shenzhen Stock Exchange; $IDIOSYNCRATIC_{t-1}$ is the stock idiosyncratic volatility calculated from Equation (25); $CONSTRAINT1_{t-1}$ implies whether the stock can be shortened or not, $CONSTRAINT1_{t-1} = 1$ means the stock can be shortened, and $CONSTRAINT1_{t-1} = 0$ means the stock cannot be shortened. The variable $CONSTRAINT2_{t-1}$ is calculated from sample in and since 2009, $CONSTRAINT2_{t-1} = 1$ means the stock can be shortened, and $CONSTRAINT2_{t-1} = 0$ means the stock cannot be shortened. Table 4 presents the cross terms of the financial report quality and the investor sentiment in columns (1) and (5) have coefficients, −0.0005 and −0.0002, which are significantly negative at the 5 percent level. Such results indicate that a higher information disclosure reduces the positive relation between investor sentiment and crash risk. In columns (2) and (6), the cross terms of idiosyncratic volatility and investor sentiment $IDIOSYNCRATIC_{t-1}$*$SENTIMENT_{t-1}$ have negative coefficients, −0.0021 and −0.0010, which are significant at the 1 percent level. We conclude that a higher idiosyncratic volatility (the stock price reveals more private information) reduces the positive relation between investor sentiment and crash risk. The cross terms of the absence of short-sale constraint and investor sentiment have negative coefficients, which are significant at the 5 percent or 1 percent level. This result indicates the absence of short-sale constraint reduces the positive relationship between investor sentiment and crash risk significantly. The robustness tests are in keeping with the conclusions in the main body above.

We also follow Hutton, Marcus, and Tehranian (2009) to define the crash. If the weekly return of the stock is 3.09 times standard deviation less than the expected return, the crash happens. We choose the figure 3.09 because the figure corresponds with the probability of 0.1 percent in the normal distribution. If the crash happens, CRASH = 1. Otherwise, CRASH = 0. Table 5 demonstrates the robustness of the conclusion by redefining the crash risk and employing the logit regression. The results indicate that the relationship between the investor sentiment and the crash risk is significantly positive. Furthermore, a higher financial report quality, the less private information revealed in stocks, the absence of short-sale constraints, and bull markets can strengthen the positive relationship above. The robustness tests are consistent with the conclusions in the main body above.

Conclusion

This article employs the rational models with incomplete information aggregation into the frame of behavioral finance and study how investor sentiment affects stock return and the relationship between investor sentiment and crash risk in different conditions. By using data of listed companies in the China Shanghai and Shenzhen A share market, we set variables to describe investor sentiment and the potential of crash, and find that the investor sentiment is positively related to future stock price crash risk and poorer financial report quality and short-sale constraint will strengthen this association. What's more, the less private information revealed in stocks, the absence of short-sale constraints and bull market state will strengthen such a positive association.

Table 4. Robustness test: Investor sentiment and crash risk

	$NCSKEW_t$				$DUVOL_t$			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$SENTIMENT_{t-1}$	0.0044**	0.0053***	0.0039***	0.0054***	0.0016*	0.0023***	0.0008**	0.0014***
	(2.32)	(4.74)	(4.10)	(6.78)	(1.71)	(4.52)	(2.49)	(3.73)
$INFO_{t-1}$*$SENTIMENT_{t-1}$	−0.0005**				−0.0002**			
	(−2.63)				(−2.39)			
$INFO_{t-1}$	−0.0779**				−0.0395**			
	(−2.46)				(−2.57)			
$IDIOSYNCRATIC_{t-1}$*$SENTIMENT_{t-1}$		−0.0021***				−0.0010***		
		(−3.00)				(−3.03)		
$IDIOSYNCRATIC_{t-1}$		0.1294***				0.0184		
		(3.95)				(1.23)		
$CONSTRAINT1_{t-1}$*$SENTIMENT_{t-1}$			−0.0048**				−0.0065**	
			(−2.05)				(−2.63)	
$CONSTRAINT1_{t-1}$			0.1486*				0.0960**	
			(1.92)				(2.29)	
$CONSTRAINT2_{t-1}$*$SENTIMENT_{t-1}$				−0.0082**				−0.0077***
				(−2.63)				(−3.21)
$CONSTRAINT2_{t-1}$				0.1540*				0.0986**
				(1.86)				(2.49)
LEV_{t-1}	−0.1887	−0.1301	−0.3884*	−0.2026	−0.0241	−0.0274	−0.1745	−0.0755
	(−1.30)	(−1.45)	(−1.96)	(−1.20)	(−0.34)	(−0.67)	(−1.62)	(−0.93)
MB_{t-1}	0.2321***	0.2801***	0.1014	0.1934**	0.1769***	0.1997***	0.1271**	0.1580***
	(3.59)	(6.85)	(1.07)	(2.41)	(5.65)	(10.67)	(2.48)	(4.12)
RET_{t-1}	−5.4103***	−7.8608***	0.4766	−7.7864***	−3.1619***	−3.4734***	−0.3770	−4.2275***
	(−4.26)	(−9.08)	(0.21)	(−4.94)	(−5.15)	(−8.77)	(−0.30)	(−5.62)
ROA_{t-1}	−0.2257**	−0.0470	−0.7074**	−0.2781	−0.0283	0.0230	−0.3111*	0.0030
	(−2.32)	(−1.28)	(−2.28)	(−0.99)	(−0.60)	(1.36)	(−1.85)	(0.02)
$SIGMA_{t-1}$	1.3918***	1.8250***	−0.0936	1.6590***	0.6926***	0.7578***	0.0128	0.7991***
	(4.84)	(8.12)	(−0.20)	(4.69)	(4.98)	(7.37)	(0.05)	(4.73)
$SIZE_{t-1}$	−0.0212	0.0011	−0.0382*	−0.0510***	0.0318***	0.0361***	0.0096	0.0206**
	(−1.26)	(0.13)	(−1.83)	(−3.19)	(3.89)	(8.97)	(0.85)	(2.69)

$NATURE_{t-1}$	−0.0115	0.0022	−0.0292	−0.0026	−0.0365**	−0.0326***	−0.0123	−0.0113
	(−0.36)	(0.12)	(−0.71)	(−0.07)	(−2.36)	(−3.77)	(−0.55)	(−0.66)
$HOLD_{t-1}$	0.0024	−0.0019	−0.0064**	0.0004	−0.0035**	−0.0041***	−0.0053***	−0.0030***
	(0.91)	(−1.33)	(−2.69)	(0.17)	(−2.79)	(−6.35)	(−4.12)	(−2.96)
_CONS	0.5733*	−0.1496	1.0862***	0.9108***	−0.4187**	−0.5926***	−0.0019	−0.3074**
	(1.92)	(−0.98)	(3.08)	(3.40)	(−2.90)	(−8.45)	(−0.01)	(−2.40)
IND_DUM	YES	YES	YES	YES	YES	YES	YES	YES
FIRM EFFECT	YES	YES	YES	YES	YES	YES	YES	YES
OBS	3071	9179	1537	2488	9179	3071	1537	2488
ADJ_R2	0.0263	0.0264	0.0599	0.0453	0.0512	0.0362	0.0447	0.0481

Notes: INFOt-1 is the quality of listed company information disclosure in Shenzhen Stock Exchange, it equals 1 to 4, the bigger number means better financial report quality; IDIOSYNCRATICt-1 is the stock idiosyncratic volatility calculated from Equation (25); CONSTRAINT1 t-1 and CONSTRAINT2 t-1 are both binary variables. CONSTRAINT1 t-1 implies whether the stock can be shortened or not, CONSTRAINT1 t-1 = 1 means the stock can be shortened, and CONSTRAINT1 t-1 = 0 means the stock cannot be shortened. The variable CONSTRAINT2 t-1 is calculated from a sample from 2009, CONSTRAINT2 t-1 = 1 means the stock can be shortened, and CONSTRAINT2 t-1 = 0 means the stock cannot be shortened. Here *, **, and *** indicate statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively.

Table 5. Robustness test

	$CRASH_t$				
	(1)	(2)	(3)	(4)	(5)
$SENTIMENT_{t-1}$	0.0073***	0.0071***	0.0175***	0.0074***	0.0091***
	(6.66)	(6.34)	(10.75)	(6.68)	(8.38)
$ACCM_{t-1}$*$SENTIMENT_{t-1}$		0.0020**			
		(2.00)			
$ACCM_{t-1}$		0.0178			
		(0.49)			
$SYNCH_{t-1}$*$SENTIMENT_{t-1}$			−0.0037***		
			(−6.54)		
$SYNCH_{t-1}$			0.3683***		
			(15.57)		
$CONSTRAINT_{t-1}$*$SENTIMENT_{t-1}$				−0.0169**	
				(−2.22)	
$CONSTRAINT_{t-1}$				0.1107	
				(0.53)	
$MARKET_{t-1}$*$SENTIMENT_{t-1}$					−0.0041**
					(−2.62)
$MARKET_{t-1}$					0.9565***
					(11.77)
LEV_{t-1}	−0.1918	−0.1951	−0.3282	−0.1854	−0.0671
	(−0.86)	(−0.87)	(−1.44)	(−0.83)	(−0.30)
MB_{t-1}	0.4294***	0.4287***	0.7392***	0.4296***	0.0193
	(4.30)	(4.29)	(7.18)	(4.28)	(0.18)
RET_{t-1}	−11.3361***	−11.2235***	−15.0898***	−11.5073***	−7.2545***
	(−5.13)	(−5.07)	(−6.61)	(−5.20)	(−3.28)
ROA_{t-1}	−0.4018**	−0.4191**	−0.1214	−0.4028**	−0.4104**
	(−2.06)	(−2.13)	(−0.82)	(−2.06)	(−2.03)
$SIGMA_{t-1}$	13.0003***	13.0557***	14.2847***	12.9624***	5.9765***
	(10.33)	(10.34)	(11.01)	(10.29)	(4.90)
$SIZE_{t-1}$	−0.1184***	−0.1178***	−0.0651***	−0.1155***	−0.0170
	(−5.33)	(−5.30)	(−2.87)	(−4.87)	(−0.72)
$NATURE_{t-1}$	−0.0529	−0.0513	0.0051	−0.0503	−0.0968**
	(−1.13)	(−1.09)	(0.11)	(−1.07)	(−2.04)
$HOLD_{t-1}$	0.0044	0.0041	0.0007	0.0045	−0.0063*
	(1.27)	(1.17)	(0.20)	(1.28)	(−1.75)
_CONS	0.1498	0.1558	−1.8274***	0.1089	−0.8484**
	(0.40)	(0.42)	(−4.58)	(0.28)	(−2.22)
IND_DUM	YES	YES	YES	YES	YES
OBS	9179	9179	9179	9179	9179
Pseudo R2	0.0348	0.0359	0.0582	0.0350	0.0487

Notes: This table presents the robustness test. We follow Hutton, Marcus, and Tehranian (2009) to define the crash. If the weekly return of the stock is 3.09 times standard deviation less than the expected return, the crash happens. We choose the figure 3.09 because the figure corresponds with the probability of 0.1 percent in the normal distribution. If the crash happens, CRASH = 1. Otherwise, CRASH = 0. Here *, **, and *** indicate statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively.

Our study explores the micro-mechanism of stock crash, and demonstrates that stock crash is not only affected by the investor sentiment indicated by behavioral finance, but also influenced by the factors implied by rational models with incomplete information aggregation, especially the transaction system like short-sale constraint. For one thing, our findings help the investors recognize the reliability

of expectations about stock returns, especially in the bull market state, stock price crash may happen in the short future. For another, our conclusions offer theoretical and empirical supports to policymakers and market regulators to carry out policies to improve financial report quality and to develop trade products, especially hedge transaction products.

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