

Short selling and stock price crash risk

Short selling
and stock price

Jay M. Chung

*School of Finance, College of Business Administration, Soongsil University,
Seoul, Republic of Korea, and*

Shu-Feng Wang

College of Business Administration, Ajou University, Suwon, Republic of Korea

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Abstract

This paper aims to investigate short selling and stock price crash risk. The authors find that short selling is positively associated with one-month-ahead stock price crash risk, consistent with the literature showing that short sellers are informed traders. The authors attribute this prediction ability to the information short sellers receive from foreign investors with high levels of ownership in a firm. The results shed light on policy issues regarding short selling regulation.

Keywords Foreign ownership, Short selling, Crash risk

Paper type Research paper

1. Introduction

Prior studies show that short sellers are considered well-informed, sophisticated traders (Diamond and Verrecchia, 1987; Asquith and Meulbroek, 1995; Asquith, Pathak and Ritter, 2005; Desai *et al.*, 2006; Boehmer *et al.*, 2008; Diether *et al.*, 2009). They show that the shorting volume increases before the dates of such events as earnings announcements and analyst downgrades (Christophe *et al.*, 2004, 2010). In this paper, we attempt to find evidence on potential sources of information used by short sellers, especially foreign short sellers in an emerging market. There has been much debate on the information advantages of foreign investors in overseas markets. Froot *et al.* (2001) and Froot and Ramadorai (2008) show that foreign investors are informed and Seasholes (2004) investigates foreign investors' informational advantage in an emerging market, finding that foreign investors perform better than domestic investors in large and well-known firms in the equity market. While Brennan and Cao (1997), Grinblatt and Keloharju (2000) and Griffin *et al.* (2007) report the opposite finding. They show that foreign investors are disadvantage in information relative to domestic investors, therefore, they use momentum trading strategy. Dvořák (2005) and Choe *et al.* (2005) investigate informational advantage of foreign investors and find that domestic investor earn higher profit in Indonesian and Korean stock market, respectively.

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We investigate whether foreign short sellers, which are known as informed traders, in an emerging market are able to predict stock price crash and their sources of information. We focus on the Korean stock market because in 1997 legal limitations on foreign investor ownership were fully abolished, allowing foreign investors to actively sell short under less binding regulations [1]. Wang and Lee (2015) show that about 80%–90% of the daily total shorted volume in Korea is due to foreign investors, whereas only 10%–20% of the total shorted volume is due to individual and domestic institutional investors, suggesting that foreign investors are the major player in the short selling market [2].

Callen and Fang (2015) show that bad news hoarding leads to stock price crash risk and that short sellers are skilled in identifying such bad news in the USA. In this paper, we first examine whether short sellers predict stock price crash and then identify the source of their information. One possible source of information is tips received from foreign investors with high shares of ownership in a firm. We hypothesize that short sellers shorting a stock with a high level of foreign ownership are more likely to predict stock price crash. Although we do not have direct evidence of a “tipping” behavior link, our empirical evidence result leans toward the tipping trade.

We contribute to the literature by showing that short sellers identify firm bad news and that this news is provided by other foreign investors in the firm (tipping trade). Few papers investigate short sellers’ information sources and some find that short sellers receive analyst downgrade information from brokerage firms (Christophe *et al.*, 2010). Other papers show that short sellers have superior information processing skills (Engelberg *et al.*, 2012). We add evidence on how informed short sellers in an emerging market obtain information. We find that short trading in the Korean stock market is not as active as in the USA market. Over 50% of stock–day observations have no shorting flow, and about 3% of total firms listed on the Korea Composite Stock Price Index (KOSPI) market have no shorted shares over the sample period. Moreover, we find that only 11% of total firms exhibit a level of relative short selling activity (*relss*) above 5%, where relative short selling activity (*relss*) is defined as the number of shorted shares divided by the number of traded shares. We find average *relss* to be 3.6% after screening out stocks with small short sale volumes. Compared to the USA, with *relss* of 24% and 31% on the New York stock exchange (NYSE) and Nasdaq, respectively, short selling in the Korean stock market focuses on only a few firms.

We also find that short sellers are able to predict one-month-ahead stock price crash. This result is consistent with Callen and Fang (2015), the difference being that they use one-year-ahead crash risk measures, whereas we use one-month-ahead measures. We use one-month-ahead crash risk measures because, given the high cost of long-term investment, short sellers prefer short-term investment (Morck *et al.*, 1990). The relative short selling activity and one-month-ahead stock price crash measures are positive and significant, suggesting that short sellers predict stock price crash. We also provide robustness tests to confirm that our results are not driven by the 2008 global financial crisis or short-term crash risk measures. Finally, we investigate short sellers’ possible sources of information. We separate the sample into two subsamples based on firm foreign ownership. We find the ability to predict short selling only in stocks with high levels of foreign ownership, suggesting that short sellers receive firm bad news from foreign investors with high shares of ownership in those firms.

Our findings shed light on important policy issues regarding short selling regulation. We provide evidence that tipping could be common in short selling trade. Thus, our paper calls into question the fairness of certain investors participating in short selling trade.

The remainder of the paper is organized as follows. Section 2 describes the data and sample, as well as the construction of the measures. Section 3 presents the empirical results and robustness tests. Section 4 provides evidence on the source of short sellers' information. The paper concludes in Section 5.

2. Data and sample

2.1 Sample construction

We obtain data on daily stock returns, daily short selling volumes, market capitalization, daily trading volumes and financial statements for stocks listed in the KOSPI market from January 1, 2006 to December 12, 2018, from FnDataGuide, one of the biggest data vendors in Korea. We exclude those stocks with fewer than 250 trading days over the sample period. We also drop observations missing monthly stock returns, trading volumes and short selling volumes. We further drop stock-year observations if the book-to-market ratio, leverage ratio or return on assets (*ROA*) is not available that year. Following Diether *et al.*, (2009), we measure the monthly relative short selling activity of stock i in month t , denoted $relss_{i,t}$, as the average daily ratio of the shorted share to the trading volume within the month:

$$relss_{i,t} = Avg \left[\frac{\# \text{shorted share}_{i,d}}{\# \text{traded share}_{i,d}} \right]$$

Wang and Lee (2015) show that $relss$ quite low in Korea compared to the USA, 78% of their stock-day observations have $relss$ equal to zero. To avoid potential confounding effects on the empirical results, especially for monthly $relss$, we first examine the sample stock-day observations of $relss$. Table 1 shows the distribution of stock-day observations of $relss$ for 900 stocks, with 3,701,075 stock-day observations in the KOSPI market.

Panel A of Table 1 shows the stock-day observations of $relss$. A total of 53.79% of stock-day observations have no short selling activity and 40.96 % of stock-day observations have $relss$ less than 10 %. The Column 1 in Panel B shows the average number of firms in each range of $relss$ shown. For each stock, we calculate the average daily $relss$ over the sample period and group them accordingly. We see that over 3% of firms' $relss$ are zero and that about 50% of firms' $relss$ are less than 1 %. In Panel C, we show the portion of nonzero short selling that is we calculate the number of nonzero $relss$ stock-day observations, divided by the total number of days for each stock over the sample period. The result shows that 55.2% of firms have an average nonzero $relss$ ratio of less than 50%, suggesting that use of the full sample to perform analyzes could result in bias in the empirical analysis.

Given the rarity of short selling in the Korean stock market, we restrict our sample to stocks with a nonzero $relss$ ratio above 50% over the sample period. After all screening, our final sample consists of 400 firms with 45,228 stock-month observations.

2.2 Stock price crash risk

To examine the relation between stock price crash risk and short selling activity, we need to construct stock price crash risk. Following Chen *et al.* (2001), we construct two stock price crash risk measures for each firm in each month. The first measure is *Skewness*, which is defined as the negative coefficient of the skewness of firm-specific daily returns. Specifically, we first estimate firm-specific daily returns from the regression of daily stock returns on lead and lag terms for the market and industry index returns for each firm each month. We include lead and lag terms for the market and industry indexes for allow nonsynchronous trading. The specification is as follows:

Range	No. of stock-day obs.	(%)	
<i>Panel A: Stock-day observations</i>			
<i>relss</i> = 0%	1,412,399	53.79	
0% < <i>relss</i> ≤ 10%	1,075,376	40.96	
0% < <i>relss</i> ≤ 1%	493,377	18.79	
1% < <i>relss</i> ≤ 2%	167,446	6.38	
2% < <i>relss</i> ≤ 3%	108,737	4.14	
3% < <i>relss</i> ≤ 4%	78,692	3.00	
4% < <i>relss</i> ≤ 5%	60,655	2.31	
5% < <i>relss</i> ≤ 6%	47,723	1.82	
6% < <i>relss</i> ≤ 7%	38,495	1.47	
7% < <i>relss</i> ≤ 8%	31,424	1.20	
8% < <i>relss</i> ≤ 9%	26,384	1.00	
9% < <i>relss</i> ≤ 10%	22,443	0.85	
10% < <i>relss</i> ≤ 20%	104,281	3.97	
20% < <i>relss</i> ≤ 30%	25,474	0.97	
<i>relss</i> > 30%	8,169	0.31	
Total	3,701,075	100.00	
<i>Panel B: Stock observations</i>			
Range	No. of stocks	(%)	
<i>relss</i> = 0%	29	3.22	
0% < <i>relss</i> ≤ 1%	428	47.56	
1% < <i>relss</i> ≤ 2%	143	15.89	
2% < <i>relss</i> ≤ 3%	89	9.89	
3% < <i>relss</i> ≤ 4%	66	7.33	
4% < <i>relss</i> ≤ 5%	41	4.56	
<i>relss</i> > 5%	104	11.56	
Total	900	100.00	
<i>Panel C: Portion of non-zero short selling</i>			
Range	Non-zero <i>relss</i> ratio	No. of stocks	(%)
<i>relss</i> = 0%	0.00	29	3.22
0% < <i>relss</i> ≤ 10%	4.99	84	9.33
10% < <i>relss</i> ≤ 20%	15.09	82	9.11
20% < <i>relss</i> ≤ 30%	25.79	91	10.11
30% < <i>relss</i> ≤ 40%	35.06	104	11.56
40% < <i>relss</i> ≤ 50%	44.19	107	11.89
50% < <i>relss</i> ≤ 60%	55.06	78	8.67
60% < <i>relss</i> ≤ 70%	65.48	84	9.33
70% < <i>relss</i> ≤ 80%	75.01	67	7.44
80% < <i>relss</i> ≤ 90%	84.59	82	9.11
<i>relss</i> > 90%	95.68	92	10.22
Total		900	100.00

Table 1.
Distribution of
average relative
short selling

$$R_{i,t} = \alpha_i + \beta_{1,j}R_{m,t-1} + \beta_{2,j}R_{ind,t-1} + \beta_{3,j}R_{m,t} + \beta_{4,j}R_{ind,t} + \beta_{5,j}R_{m,t+1} + \beta_{6,j}R_{ind,t+1} + \varepsilon_{i,t} \quad (1)$$

where $R_{i,t}$ is the return on stock i on day t , $R_{m,t}$ is the return on the KOSPI on day t and $R_{ind,t}$ is the value-weighted average individual stock return for each industry ind on day t . The industry classification is that of the Korea stock exchange. Specifically, we estimate equation (1) for a given stock in a given month and use the logarithmic value of one plus the

residual $(1+r_{i,t})$ as the firm-specific daily return $(r_{i,t})$. We then defined *Skewness* as the coefficient of the monthly skewness of firm-specific daily returns, as follows:

$$Skewness_{i,t} = -\frac{(n(n-1))^{\frac{3}{2}} \sum r_{i,t}^3}{(n-1)(n-2) \left(\sum r_{i,t}^2 \right)^{\frac{3}{2}}} \quad (2)$$

Another stock price crash risk measure is *Down-to-Up*, which is the ratio of the standard deviation of down days, in terms of firm-specific daily returns, to the standard deviation of up days, as follows:

$$Down - to - Up_{i,t} = \log \left\{ \frac{(n_{Down} - 1) \sum_{Down} r_{i,t}^2}{(n_{Up} - 1) \sum_{Up} r_{i,t}^2} \right\} \quad (3)$$

For both two stock price crash risk measures, we drop stock-month observations if a stock has fewer than 10 trading days in a given month.

2.3 Control variables

We use a set of control variables that potentially affect to our stock price crash risk measures. Following [Chen et al. \(2001\)](#), we use *Daily ret*, *Kurtosis*, *Sigma*, *LnSize*, *Abnormal tv*, *B/M* ratio, *ROA* and *Lev* as control variables, where *Daily ret* (per cent) is the average stock's daily return in a given month; *Kurtosis* is the kurtosis of firm-specific daily returns in a given month; *Sigma* is the standard deviation of firm-specific daily returns in a given month; *LnSize* is stock capitalization, defined as the logarithm of the month-end stock price times the number of shares outstanding; *Abnormal tv* is the abnormal trading volume, defined as the difference between the current month *tv* value and the previous month's, where *tv* is share turnover, which is the ratio of the monthly volume of traded shares to the number of shares outstanding that month; *B/M* ratio is the book-to-market ratio, which defined as the previous year-end book equity divided by the previous year-end market capitalization; *ROA* is the return on assets, defined as the previous fiscal year's net income divided by the previous fiscal year's total assets; and *Lev* is the leverage ratio, defined as the previous fiscal year's total liability scaled by the previous year's total assets.

3. Empirical analysis

3.1 Descriptive statistics

[Table 2](#) presents summary statistics of the stock price crash risk measures and control variables.

The mean of *relss* is 3.622% in our sample, which is higher than the *relss* reported by [Wang and Lee \(2015\)](#). Wang and Lee using 50 stocks with the highest average *relss* from January 1, 2006 to May 31, 2010. Our mean *relss* is higher than theirs because short selling activity increased significantly since 2010. [Figure 1](#) shows the *relss* of our sample. We see that *relss* increases from 2006 to 2008 and then experiences a big drop, which is the short selling ban during the financial crisis period [\[3\]](#). After 2009, short selling activity increased significantly. However, overall, the *relss* in the Korean stock market are small compared to those in the USA market [\[4\]](#). The mean values of the two stock price crash risk measures *Skewness* and *Down-to-Up* are -0.213 and -0.138 , respectively. This result is similar to that

Variables	Mean	P25	Median	P75	No. of stock-month obs.
<i>relss</i> (%)	3.622	0.581	2.246	5.111	45,288
<i>Skewness</i>	-0.213	-0.661	-0.203	0.238	45,288
<i>Down-to-Up</i>	-0.138	-0.448	-0.141	0.167	45,288
<i>Skewness</i> _{t+1}	-0.214	-0.661	-0.202	0.238	45,178
<i>Down-to-Up</i> _{t+1}	-0.138	-0.448	-0.140	0.167	45,178
<i>Daily ret</i> (%)	0.075	-0.320	0.022	0.409	45,288
<i>Kurtosis</i>	0.872	-0.379	0.303	1.439	45,288
<i>Sigma</i>	0.021	0.014	0.019	0.025	45,288
<i>LnSize</i>	13.754	12.585	13.646	14.816	45,288
<i>Trading Vol.</i>	11,613.223	1,216.146	3,603.642	9,650.232	45,288
<i>Abnormal tv</i>	-0.285	-2.726	-0.221	2.073	45,288
<i>B/M</i>	0.011	0.001	0.004	0.011	45,288
<i>ROA</i>	0.395	0.021	0.093	0.482	45,288
<i>Lev</i>	1.279	0.378	0.575	0.927	45,288

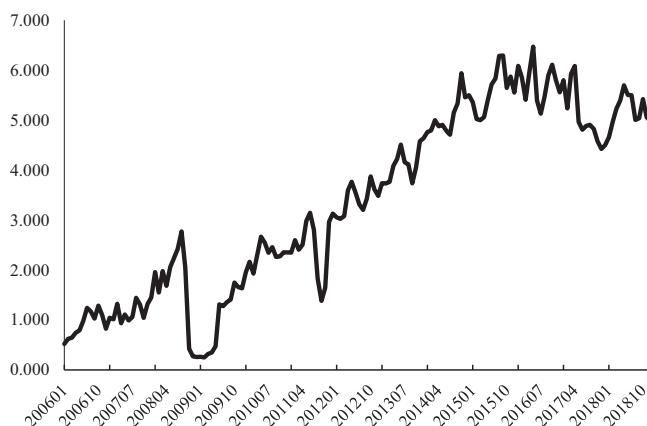
Notes: This table shows summary statistics of stock-month observations. *relss* (%) is the average daily relative short selling activity in a given month, defined as the daily short volume divided by the daily trading volume. *Skewness* is the stock price crash measure defined as the negative coefficient of skewness of firm-specific daily stock returns in a given month. The firm-specific daily stock return is the regression residual from equation (1). *Down-to-Up* is a stock price crash measure defined as the logarithm of the value of the standard deviation of down days, in terms of firm-specific daily returns, divided by the standard deviation of up days in a given month. We define down (up) days as the days for which the firm-specific daily stock return is below (above) the average in a given month. *Daily ret* (%) is the average daily stock return in a given month; *Kurtosis* is the kurtosis of firm-specific daily stock returns in a given month; *Sigma* is the standard deviation of firm-specific daily stock returns in a given month; *LnSize* is the logarithm of market capitalization in a given month; *Trading Vol.* (in thousands of shares) is the total number of shares traded in a given month; *Abnormal tv* is defined as the monthly turnover minus the previous month's turnover; *tv* is turnover, defined as the monthly total number of shares traded divided by the number of shares outstanding; *B/M* is the book-to-market ratio, defined as the value of book equity in year $t - 1$ divided by the year-end market capitalization in year $t - 1$; *ROA* is year-end net income divided by total assets; and *Lev* is the leverage ratio, defined as total liability divided by total assets

Table 2.
Summary statistics

of Chen *et al.* (2001), who, using market-adjusted returns, find *Skewness* and *Down-to-Up* values of -0.262 and -0.190 , respectively.

3.2 Portfolio analysis

In this section, we determine whether short selling activities predict stock price crash. Given that short sellers are short-term investors (Morck *et al.*, 1990; Wang *et al.*, 2017), we use one-month-ahead stock price crash risk in a portfolio analysis. Table 3 presents the results of univariate portfolio sort analysis. Specifically, for each month t , we first separate out the subsample of observations with nonzero *relss* values and then sort these into four groups based on their *relss*. We then report the time-series average of the cross-group means of *Skewness* and *Down-to-Up* in month $t + 1$, with standard errors adjusted according to Newey and West (1987). The Column 1 in Table 3 shows the *relss* ranks for the groups Zero to High. The Column 2 shows the month $t + 1$ *Skewness* values. We see that *Skewness* is monotonically increasing with *relss*. The difference between the High and Low groups is positive and significant at the 1% significance level. The Column 1 shows the results for the *Down-to-Up* measure, consistent with *Skewness*. The results in Table 3 are consistent with the work of Callen and Fang (2015), who find that short interest is positively associated with one-year-ahead stock price crash risk. Overall, our results are consistent with our hypothesis, in that short selling activities predict stock price crash.



Notes: This figure shows the relative short selling activity (*relss*) for our 400 sample stocks. The variable *relss* (%), relative short selling activity, is defined as the daily short volume divided by the daily trading volume. We average the daily *relss* for a given stock in a given month as the monthly *relss* and we report the cross-sectional mean of *relss*

Figure 1.
Relative short selling
activity for 400 stocks

Rank by <i>relss</i>	<i>Skewness</i> _{<i>t</i>+1}	<i>Down-to-Up</i> _{<i>t</i>+1}
0 (Zero)	-0.192*** (-3.92)	-0.127*** (-5.42)
1 (Low)	-0.269*** (-17.75)	-0.170*** (-17.62)
2	-0.222*** (-15.17)	-0.143*** (-15.81)
3	-0.179*** (-12.44)	-0.120*** (-13.04)
4 (High)	-0.164*** (-11.02)	-0.107*** (-11.52)
High-Low	0.106*** (8.90)	0.063*** (8.24)

Notes: This table shows the stock price crash risk according to *relss* (%). For month *t*, we first separate out the subsample for which *relss* is nonzero and then divide the nonzero *relss* sample into four groups based on *relss*. We report the time-series average of the cross-group mean of *Skewness*_{*t*+1} and *Down-to-Up*_{*t*+1}. *relss* (%) is the average daily relative short selling activity in a given month, defined as the daily short volume divided by the daily trading volume. *Skewness* is the stock price crash measure defined as the negative coefficient of skewness of firm-specific daily stock returns in a given month. The firm-specific daily stock return is the regression residual from equation (1). *Down-to-Up* is a stock price crash measure defined as the logarithm of the standard deviation of down days, in terms of firm-specific daily returns, divided by the standard deviation of up days in a given month. We define down (up) days as the days for which the firm-specific daily stock returns are below (above) the average in a given month. The *t*-statistics are in parentheses and standard errors are corrected by using the Newey–West procedure; ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively

Table 3.
One-way sort
portfolio

3.3 Regression analysis

In the portfolio analysis, we show that the significantly positive relation between short selling activity and one-month-ahead stock price crash risk suggests that short sellers predict stock price crash. In this section, we perform a formal analysis to determine whether the predictive power of short selling remains strong after controlling for other stock

characteristics that are known to predict stock price crash (Chen *et al.* (2001)). Our monthly cross-sectional regression is as follows:

$$Crash_{i,t+1} = \alpha_t + \beta_t relss_{i,t} + \gamma_t X_{i,t} + \varepsilon_{i,t+1} \quad (4)$$

where $Crash_{i,t+1}$ denotes the two stock price crash risk measures of stock i in month $t + 1$ that is *Skewness* and *Down-to-Up*; $relss_{i,t}$ is the relative short selling activity of stock i in month t ; and $X_{i,t}$ is a set of control variables for stock i in month t . The control variables are the skewness of firm-specific daily returns (*Skewness*), the kurtosis of firm-specific daily returns (*Kurtosis*), the standard deviation of firm-specific daily returns (*Sigma*), the average stock daily return (*Daily ret*), the book-to market ratio (*B/M*), the previous fiscal year's total liability scaled by total assets (*Lev*), the previous fiscal year's net income scaled by total assets (*ROA*), the logarithm of market capitalization (*LnSize*) and month t 's share turnover minus the previous month's share turnover (*Abnormal tv*).

Table 4 shows the time-series average of the coefficients from the Fama and MacBeth (1973) cross-sectional regression of one-month-ahead stock crash risk on *relss*, controlling for other firm characteristics that potentially affect stock crash risk. The t -statistics are in parentheses and standard errors are adjusted by using the Newey and West (1987) method.

Independent variables	<i>Skewness</i> _{t+1}	<i>Down-to-Up</i> _{t+1}
<i>relss</i>	0.0025* (1.84)	0.0019** (2.16)
<i>Skewness</i>	0.0128** (2.37)	0.0093*** (2.65)
<i>Kurtosis</i>	0.0015 (0.72)	0.0013 (1.18)
<i>Sigma</i>	-0.0140** (-2.21)	-0.0125*** (-3.22)
<i>Daily ret</i>	0.0058 (0.91)	0.0037 (0.95)
<i>B/M</i>	1.0979*** (3.71)	0.7436*** (4.40)
<i>Lev</i>	0.0011 (0.54)	0.0007 (0.54)
<i>ROA</i>	-0.0096* (-1.70)	-0.0056 (-1.61)
<i>LnSize</i>	0.0676*** (15.89)	0.0392*** (15.83)
<i>Abnormal tv</i>	0.0479** (2.04)	0.0321** (2.07)
R^2	0.056	0.055
<i>Adj. R</i> ²	0.021	0.020

Notes: This table reports the stock-level cross-sectional regression results of the predictability of short selling activity, using Fama and MacBeth (1973) methodology. The dependent variables are two stock price crash risk measures, *Skewness* and *Down-to-Up*, respectively. *Skewness* is the stock price crash measure defined as the negative coefficient of skewness of firm-specific daily stock returns in a given month, where the firm-specific daily stock return is the regression residual from equation (1). *Down-to-Up* is the other stock price crash measure, defined as the logarithm of the standard deviation down days, in terms of firm-specific daily returns, divided by the number of up days in a given month. We define down (up) days as the days with firm-specific daily stock returns below (above) the average in a given month. *relss* (%) is the average daily relative short selling activity in a given month, defined as the daily short volume divided by the daily trading volume; *Kurtosis* is the kurtosis of firm-specific daily stock returns in a given month; *Sigma* is the standard deviation of firm-specific daily stock returns in a given month; *Daily ret* (%) is the average daily stock return in a given month; *B/M* is the book-to-market ratio, defined as the value of book equity in year $y-1$ divided by the year-end market capitalization in year $y-1$; *Lev* is the leverage ratio, defined as total liability divided by total assets; *ROA* is year-end net income divided by total assets; *LnSize* is the logarithm of market capitalization in a given month; *Abnormal tv* is defined as monthly turnover minus the previous month's turnover; and *tv* is turnover, defined as the monthly total number of shares traded divided by the number of shares outstanding. The intercepts are estimated but are not tabulated here. The t -statistics are in parentheses, and standard errors are corrected by using the Newey–West procedure; ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively

Table 4.
Predictability of
short selling

The first specification shows the results for *Skewness*, while the second specification shows the results for *Down-to-Up* and the average coefficients of *relss* are 0.0025 and 0.0019, respectively, significant at the 10% and 5% significance levels. These results are consistent with the prior literature where short sellers are informed traders (Boehmer *et al.*, 2008; Boehmer and Wu, 2013; Christophe *et al.*, 2010; Diether *et al.*, 2009).

Overall, our results support our hypothesis, in that short sellers can predict stock price crash. In terms of the control variables, except for *Kurtosis*, *Daily ret* and *Lev*, the firm characteristic variables are consistent with the prior literature. For example, *Abnormal tv* is positive and highly significant for both equations, suggesting that, all else being equal, stocks that experience abnormally high turnover become more crash prone. Moreover, firm size is positively and significantly linked to one-month-ahead *Skewness* and *Down-to-Up*, suggesting that large firms tend to have negative skewness. The coefficients of *B/M* are positive and significant, suggesting that value stocks are more crash prone. This result is inconsistent with Harvey and Siddique (2000), Chen *et al.* (2001) and Callen and Fang (2015), who find that growth stocks are more crash prone. One possible explanation for the positive relation between *B/M* and negative *skewness* is investors' preference for positive *skewness* in stock returns. People are well known to prefer lottery stocks, which have highly right-skewed payoffs (Green and Hwang, 2012; Kahneman and Tversky, 1979). Relatedly, Zhang (2013) shows that investors' skewness-seeking behavior explains the difference in skewness across book-to-market portfolios and investors' preference for growth stocks. Zhang's results suggest that growth stocks are likely to be positively skewed.

3.4 Robustness check

We further perform a number of robustness checks. Table 5 shows the results. First, when the Financial Supervisory Service (FSS) in of Korea banned short selling for stocks listed on KOSPI and KOSDAQ from October 1, 2008, to May 31, 2009, it did not restrict investors whose purpose for selling short is to provide liquidity or to hedge underlying positions. We, therefore, exclude the short selling ban period to avoid any confounding effect. The results are show in Columns (1) and (2) of Table 5. The *relss* predicts the one-month-ahead stock price crash, with 0.0025 and 0.0019 and the *t-values* are 1.77 and 2.03 for *Skewness* and *Down-to-Up*, respectively.

Thus far, we have investigated the ability of *relss* to predict stock price crash one month ahead. We now check whether this ability to predict holds for longer horizons. In Columns (3) to (6) of Table 5, we replace one-month-ahead crash measures (*Skewness* and *Down-to-Up*) with average three-month and average six-month crash measures. We see that *relss* is positive and significant in all specifications, except when the average three-month *Down-to-Up* measure is a dependent variable. The control variables in Table 5 are the same as in Table 4.

4. Source of the predictability

Our finding of the impact of *relss* on future stock price crash risk might not imply that short sellers are informed traders. In this section, we perform an analysis to show that the ability to predict of *relss* could depend on firm characteristics. Prior literature shows that short sellers earn profits through short selling trade because they have a superior ability to process public information. For example, Engelberg *et al.* (2012) show that short sellers make profits through the superiority of their information processing skills in the USA. Wang *et al.* (2017) also find similar results, where short sellers' profits in the Korean stock market are attributed to their information processing skills. On the other hand, Christophe *et al.* (2010) investigate short selling activity prior to analyst downgrades. They find that

Table 5.
Robustness tests

Independent variables	(1)	(2)	(3)	(4)	(5)	(6)
	<i>Skewness_{t+1}</i>	<i>Down-to-Up_{t+1}</i>	<i>Skewness_{t+1~t+3}</i>	<i>Down-to-Up_{t+1~t+3}</i>	<i>Skewness_{t+1~t+6}</i>	<i>Down-to-Up_{t+1~t+6}</i>
<i>relss</i>	0.0025* (1.77)	0.0019** (2.03)	0.0015 (1.44)	0.0013* (1.81)	0.0024** (2.43)	0.0016** (2.66)
<i>Skewness</i>	0.0116** (2.01)	0.0086** (2.27)	0.0153*** (4.35)	0.0107*** (4.77)	0.0137*** (5.74)	0.0089*** (5.69)
<i>Kurtosis</i>	0.0019 (0.90)	0.0013 (1.05)	0.0009 (0.68)	0.0011 (1.39)	0.0003 (0.30)	0.0006 (1.08)
<i>Sigma</i>	-0.0145** (-2.21)	-0.0128*** (-3.15)	-0.0142*** (-2.81)	-0.0129*** (-4.31)	-0.0167*** (-3.66)	-0.0140*** (-5.25)
<i>Daily ret</i>	0.0054 (0.82)	0.0037 (0.91)	0.0044 (1.00)	0.0024 (0.88)	0.0045 (1.04)	0.0022 (0.84)
<i>B/M</i>	1.0420*** (3.37)	0.7168*** (4.08)	0.9131*** (3.48)	0.6381*** (4.26)	0.6790*** (2.92)	0.5236*** (3.90)
<i>Lev</i>	0.0005 (0.25)	0.0005 (0.39)	0.0006 (0.33)	0.0004 (0.36)	0.0006 (0.33)	0.0003 (0.30)
<i>ROA</i>	-0.0082 (-1.44)	-0.0049 (-1.36)	-0.0057 (-1.06)	-0.0033 (-1.03)	-0.0025 (-0.48)	-0.0016 (-0.52)
<i>LnSize</i>	0.0661*** (16.37)	0.0381*** (16.22)	0.0642*** (16.96)	0.0372*** (17.32)	0.0597*** (16.61)	0.0350*** (16.65)
<i>Abnormal tv</i>	0.0523** (2.13)	0.0355** (2.19)	0.0373** (2.57)	0.0261*** (2.96)	0.0293*** (2.83)	0.0229*** (3.65)
<i>R²</i>	0.055	0.054	0.087	0.084	0.121	0.116
<i>Adj. R²</i>	0.021	0.020	0.053	0.050	0.089	0.083

Notes: This table reports the results of robustness tests of the ability to predict short selling activity, using [Fama and MacBeth \(1973\)](#) methodology. The regression results in Columns (1) and (2) exclude the short selling ban period from October 2008 to May 2009. The regression results in Columns (3) and (4) show the ability to predict short selling activity for stock price crashes for up to three months (from $t + 1$ to $t + 3$). The regression results in Columns (5) and (6) show the ability of short selling activity to predict stock price crashes for up to six months (from $t + 1$ to $t + 6$). The dependent variables are the two stock price crash risk measures *Skewness* and *Down-to-Up*. *Skewness* is the stock price crash measure defined as the negative coefficient of the skewness of firm-specific daily stock returns in a given month. The firm-specific daily stock return is the regression residual from [equation \(1\)](#). *Down-to-Up* is the stock price crash measure defined as the logarithm of the standard deviation of down days, in terms of firm-specific daily returns, divided by the standard deviation of up days in a given month. We define down (up) days as the days when firm-specific daily stock returns are below (above) average in a given month. *relss* (%) is the average daily relative short selling activity in a given month, defined as the daily short volume divided by the daily trading volume; *Kurtosis* is the kurtosis of firm-specific daily stock returns in a given month; *Sigma* is the standard deviation of firm-specific daily stock returns in a given month; *Daily ret* (%) is the average daily stock return in a given month; *B/M* is the book-to-market ratio, defined as the value of book equity in year $y-1$ divided by the year-end market capitalization in year $y-1$; *Lev* is the leverage ratio, defined as total liability divided by total assets; *ROA* is year-end net income divided by total assets; *LnSize* is the logarithm of market capitalization in a given month; *Abnormal tv* is defined as monthly turnover minus the previous month's turnover; and *tv* is turnover, defined as the monthly number of total shares traded divided by the number of shares outstanding. Intercepts are estimated but are not tabulated. The *t*-statistics are in parentheses and standard errors are corrected by using the Newey–West procedure; ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

short sellers trade on information obtained from brokerage houses (i.e. tipping). Wang and Lee (2015) also show that about 80–90% of shares are shorted by foreign short sellers and individual investors and domestic investors account for the remaining 10–20%. Based on the above literature, we hypothesize that the ability to predict of *relss* is more likely to be strong for those stocks with a high share of foreign ownership. Table 6 shows the results.

Specifically, we split the sample into two groups based on foreign ownership. We classify stocks whose level of foreign ownership is above (below) the cross-sectional average value as belonging to the high (low) foreign ownership group. Foreign ownership is measure by the number of shares held by foreign investors scaled by the total number of outstanding shares at the end of the month. We report the time-series average coefficients for Fama and MacBeth (1970) cross-sectional regression. As expected, *relss* is positive and significant only in the high group. Although we do not have specific data to examine the relation between short selling and foreign ownership in detail, our empirical evidence suggests that short sellers could obtain information on a firm from foreign investors with a high ownership share in that firm.

Independent variables	<i>Skewness</i> _{t+1}		<i>Down-to-Up</i> _{t+1}	
	Low	High	Low	High
<i>Relss</i>	-0.0031 (-1.00)	0.0040** (2.15)	-0.0013 (-0.64)	0.0030** (2.28)
<i>Skewness</i>	0.0213*** (2.62)	-0.0009 (-0.11)	0.0144*** (2.89)	0.0007 (0.15)
<i>Kurtosis</i>	0.0020 (0.74)	0.0022 (0.62)	0.0015 (0.99)	0.0017 (0.74)
<i>Sigma</i>	-0.0087 (-1.38)	-0.0277*** (-2.74)	-0.0087** (-2.29)	-0.0227*** (-3.43)
<i>Daily ret</i>	0.0000 (-0.01)	0.0213 (1.63)	-0.0009 (-0.24)	0.0150* (1.81)
<i>B/M</i>	1.2690*** (4.23)	0.3996 (0.37)	0.7864*** (4.82)	0.4740 (0.72)
<i>Lev</i>	-0.0015 (-0.53)	0.0069* (1.72)	-0.0013 (-0.79)	0.0048** (2.06)
<i>ROA</i>	-0.0085 (-0.88)	-0.0136 (-1.55)	-0.0045 (-0.74)	-0.0081 (-1.54)
<i>LnSize</i>	0.0733*** (15.08)	0.0495*** (7.38)	0.0404*** (14.22)	0.0299*** (7.72)
<i>Abnormal tv</i>	0.0365 (1.33)	0.2090 (1.53)	0.0264 (1.53)	0.1177 (1.44)
<i>R</i> ²	0.071	0.116	0.070	0.112
<i>Adj. R</i> ²	0.014	0.021	0.014	0.017

Notes: This table shows the Fama and MacBeth (1973) regression results of the ability of short selling to predict one-month-ahead stock price crash, by foreign ownership. We split the sample into two groups, based on foreign ownership. If a stock's foreign ownership is above (below) the cross-sectional average, we classify it in the High (Low) group. The dependent variables are the two stock price crash risk measures, *Skewness* and *Down-to-Up*. *Skewness* is the stock price crash measure defined as the negative coefficient of the skewness of firm-specific daily stock returns in a given month. The firm-specific daily stock return is the regression residual from equation (1). *Down-to-Up* is the stock price crash measure defined as the logarithm of the standard deviation of down days, in terms of firm-specific daily returns, divided by the standard deviation of up days in a given month. We define down (up) days as the days with firm-specific daily stock returns below (above) the average in a given month. *relss* (%) is the average daily relative short selling activity in a given month, defined as the daily short volume divided by the daily trading volume; *Kurtosis* is the kurtosis of firm-specific daily stock returns in a given month; *Sigma* is the standard deviation of firm-specific daily stock returns in a given month; *Daily ret* (%) is the average daily stock return in a given month; *B/M* is the book-to-market ratio, defined as the value of book equity in year *y*-1 divided by the year-end market capitalization in year *y*-1; *Lev* is the leverage ratio, defined as total liability divided by total assets; *ROA* is year-end net income divided by total assets; *LnSize* is the logarithm of market capitalization in a given month; *Abnormal tv* is defined as monthly turnover minus the previous month's turnover; and *tv* is turnover, defined as the monthly total number of shares traded divided by the number of shares outstanding. Intercepts are estimated but not tabulated. The *t*-statistics are in parentheses, and standard errors are corrected by using the Newey–West procedure; ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively

Table 6.
Predictability of
short-selling on price
crash risk with
foreign ownership

5. Conclusion

This paper investigates short selling activity and future stock crash risk. Using relative short selling activity (*relss*) and the one-month-ahead negative skewness coefficient of daily stock returns, we find that short selling activity predicts future stock crash. The results are robust to both a portfolio analysis and a multivariate regression framework. Engelberg *et al.* (2012) find that short sellers have superior ability to analyze public information, while Christophe *et al.* (2010) find that short sellers receive information from brokerage houses, suggesting tipping. We also find results consistent with those of Christophe *et al.* (2010), in that short sellers receive stock price crash risk information from firms that have high levels of foreign ownership. As, in the Korean stock market, foreign short sellers account for 80% of the total number of shorted shares, we can infer that foreign traders are tipping. Our paper extends the literature on short sellers' or foreign investors' behavior in emerging markets by showing that the information of short sellers, especially foreign short sellers, is obtained not from the skilled stock analysis but, rather, from tips by foreign investors who have a high share of ownership in firms.

Our paper sheds light on the important issues regarding short selling policy making. Recently, many have been attempting to abolish or restrict short selling trade in the Korean stock market, arguing that current short selling-related policy favors domestic institutional investors and foreign investors in term of stock borrowing. We provide little evidence of potential collusion between short sellers and foreign investors, which could provide useful information to policymakers.

Notes

1. The Korean stock market introduced covered short selling to institutional investors in September 1997 and to foreign investors in July 1998.
2. As foreign short sellers are a big player in the Korean stock market, we use the daily shorting flow to proxy for foreign shorting flow. We also use the terms *short sellers* and *foreign short sellers* interchangeably.
3. The Financial Supervisory Service prohibited the short selling of all stocks listed on KOSPI and KOSDAQ from October 1, 2008, to May 31, 2009.
4. Diether *et al.* (2009) find *relss* of 24% and 31% for the NYSE and Nasdaq, respectively.

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Further reading

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Corresponding author

Shu-Feng Wang can be contacted at: sfwang@ajou.ac.kr

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