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Emissions Trading Scheme and Stock Price Crash Risk:Evidence from China

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Abstract

This paper examines the effect of emissions trading participation on stock price crash risk. Our findings support the management obfuscation hypothesis. Firms that participate in emissions trading tend to experience higher probability of stock price crash risk. Such effect is attenuated in state-owned enterprises, firms with high board independence, and efficiency. Our findings are useful for policy makers and investors who aim to manage tail risk and invest in emerging markets with weak corporate governance and agency problems.

***Keywords**:* Emissions trading; Stock price crash risk; State-owned enterprises; Board independence; Board efficiency

1. Introduction

An increasingly higher level of attention has been paid on environmental sustainability for the past few years throughout many companies around the world. A large strand of literature documents that firms with outstanding environmental performance have advantages of lower costs of financing (see e.g., Dhaliwal, Huang, Khurana, & Pereira, 2014; El Ghoul, Guedhami, & Kim, 2017; Nandy & Lodh, 2012); less prone to real earnings management (Kim, Park, & Wier, 2012) and better credit ratings (Attig, El Ghoul, Guedhami, & Suh, 2013). Despite all these positive effects, Barnea and Rubin (2010) argue that it is likely that firms' managers seek private benefits and build their reputation as good global citizens through overinvestment in environmental commitment. In addition, prior studies contend that managers might seek ways to obscure information through complicated disclosure in order to conceal firms' real performance and cover their real intentions, known as management obfuscation hypothesis (see e.g., Merkl-Davies & Brennan, 2007). This paper aims to reveal the mask by examining the effect of emissions trading scheme participation on stock price crash risk.

We find that firms that participating in emissions trading scheme exhibit higher subsequent stock price crash risk. Our results support management obfuscation hypothesis by providing evidence that managers tend to obfuscate negative news by

adopting green-related activities as a mask. The main results remain quantitatively unchanged after addressing endogeneity issue by adding firm fixed effects and instrumental variable. Moreover, our additional analyses show that state-owned enterprises, board independence and efficiency have mediating effects on managers' obfuscation behavior.

Our study provides several contributions as follows. First, we provide extensive evidence on management obfuscation hypothesis by documenting a new and green way of obfuscation. Second, we complement stock price crash risk related literature by providing more potential but neglected factors. Finally, this study provides implications for both policy makers and investors. First, we offer insight that green-related activities are not necessarily positive. Second, increased monitoring and internal governance could lower the probability of management obfuscation.

The remainder of this paper is organized as follows. Section 2 discusses the related literature and develops the hypotheses. Section 3 describes the sample, variables, and models. Section 4 presents the empirical findings. Section 5 provides robustness checks, and Section 6 concludes.

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2. Literature Review and Hypotheses Development

Crash risk is regarded as a critical characteristic of returns' distribution and is widely adopted as a measure of asymmetry in risk. Firm-specific crash risk is when managers tend to keep bad news from investors and stock prices crash when the accumulated bad news comes out (Hutton, Marcus, & Tehranian, 2009; Jin & Myers, 2006). Related studies have shown that firms in opaque countries have a higher probability to experience crash risk mainly because managers have incentives to hide negative news from investors, which is facilitated by opacity (Hutton et al., 2009; Jin & Myers, 2006). Moreover, firms that tend to avoid tax (Kim, Li, & Zhang, 2011b) and firms with equity incentives (Kim, Li, & Zhang, 2011a) have a positive relationship with crash risk, while managers working in state-owned enterprises who enjoy excess perks have more incentives to withhold bad news that can result in crash risk (Xu, Li, Yuan, & Chan, 2014).

The importance of CSR has been growing dominantly in the business world in recent years, and many studies on CSR are also emerging as CSR becomes increasingly important in corporations. It has occurred to investors that firms with higher engagement in CSR are relatively more attractive due to transparent financial disclosure. Many advocates of CSR argue that CSR activities serve as a transmission of managers' higher ethical and moral standards. Engaging in CSR activities makes managers tend

to operate with integrity and can increase their transparency of financial reporting. In line with this thought, Kim et al. (2012) find that firms that are highly engaged in CSR activities are less prone to real earnings management. In addition, firms that are highly engaged in CSR activities disclose their financial reporting more willingly (Gelb & Strawser, 2001). Furthermore, firms that engage in corporate philanthropic giving tend to care about their investors' interests more via transparency of financial reporting (Qian, Gao, & Tsang, 2015).

Based on the literature discussed above, we conjecture that managers have less incentives to benefit themselves or save their careers by hiding unfavorable news from investors and minority shareholders due to the fact that the transparency of financial reporting increases as firms place more emphasis on being outstandingly socially responsible. Firms also get noticeable attention from publicity when engaging more in environmentally or socially friendly activities that will increase managers' moral and ethical standard and thus reduce real earnings management. Based on the arguments above, our first hypothesis is developed as follows.

Hypothesis 1a: *Firms participating in emissions trading scheme experience a lower level of crash risk.*

According to information obfuscation hypothesis, managers might obfuscate or withhold negative news in order to gain private benefits (see e.g., Liu, Wang, Xue,

Linnenluecke, & Cai, 2022; Nadeem, 2022). Prior studies also note that increased operation and governance risks occur as managers camouflage unfavorable information and distract shareholder monitoring in order to accomplish personal objective (Kothari, Shu, & Wysocki, 2009). In addition, as higher expenditure in CSR might be consistent with firm value maximization, Barnea and Rubin (2010) argue that it is likely that firms' insiders such as managers or large shareholders overinvest in order to seek private interests and build their reputation as good global citizens. From the perspective of information asymmetry and agency problems, previous studies have documented that managers are inclined to overinvest when they could obtain private benefits from investing in environmental related projects (see e.g., Cronqvist & Yu, 2017; Masulis & Reza, 2015).

Therefore, participating in green-related activities, such as emissions trading scheme, could be an ideal mask for managers to conduct self-interested projects at the costs of shareholders. We hereby contend that such managers are more prone to hoard bad news, leading to subsequent stock price crash risk. The argument above leads us to the following hypothesis.

Hypothesis 1b: *Firms participating in emissions trading scheme experience a higher level of crash risk.*

3. Data and Methodology

3.1 The sample

For the proxy of whether firms participating in any emissions trading initiative, we collect data on the Emissions Trading (ENERDP068) from the Thomson Reuters (ASSET4) database between 2008 and 2020 and exclude regulated financial firms. Note that if a company claims to participate in an emission trading scheme in the future we grade as false. We then match the emissions trading proxy with the stock price data from the Thomson Reuters Datastream for all Chinese A share listed firms in order to construct proxies of future stock price crash risk. We further utilize financial data that are available in Thomson Reuters Datastream to the construct control variables for crash risk. Our final sample spans from 2008 to 2020 with 905 firm-year unbalanced observations.

3.2 Crash risk measures

In this paper we adopt *NCSKEW*, which is the negative value of return skewness, and *DUVOL*, which is the volatility of weekly returns' downs and ups, as proxies for crash risk, which are in line with prior literature (Chen, Hong, & Stein, 2001; Kim et al., 2011a, 2011b; Kim, Li, & Li, 2014). We obtain these two proxies from the residuals after performing a market model regression. Due to the fact that our interests lie solely in factors that are specific to firms instead of movements in markets, we adopt returns that are specific to firms. We measure the weekly return from Wednesday to Wednesday

to avoid the weekend effect and perform a market model regression as shown in equation (1):

$$R_{i,\tau} = \alpha_i + \beta_1 R_{m,\tau-2} + \beta_2 R_{m,\tau-1} + \beta_3 R_{m,\tau} + \beta_4 R_{m,\tau+1} + \beta_5 R_{m,\tau+2} + \varepsilon_{i,\tau} \quad (1)$$

As presented in equation (1), $R_{i,\tau}$ is the return of stock *i* in week τ, and $R_{m,\tau}$ is the return on the Taiwan Stock Exchange Capitalization Weighted Stock Index in week τ. We include previous and post-market returns for an adjustment of trading that is not synchronous (Dimson, 1979). Returns that are specific to firms are obtained as in equation (2) by using $\varepsilon_{i,\tau}$, the residual in market model regression in the first equation.

$$W_{i,\tau} = \ln(1+\varepsilon_{i,\tau}) \quad (2)$$

We construct one of the proxies of crash risk by equation (3). Here, $W_{i,\tau}$ is the weekly return specific to firms, *n* indicates the number of weekly returns during year *t*, and $NCSKEW_{i,t}$ indicates firm-specific returns that lie to the left of the skewness distribution. The higher is the negative value of $NCSKEW_{i,t}$, the higher is the crash risk that firms will experience.

$$NCSKEW_{i,t} = -\left[n(n-1)^{3/2} \sum W_{i,\tau}^3 \right] \Big/ \left[(n-1)(n-2)(\sum W_{i,\tau}^2)^{3/2} \right] \quad (3)$$

The measure for the other proxy of crash risk (*DUVOL*) is presented in equation (4)

by dividing the weekly returns that are specific to firms into two groups. One has $W_{i,\tau}$ higher than the mean value at year *t* (*Up*), and the other presents returns that are lower than the mean value (*Down*). As equation (4) shows, $DUVOL_{i,t}$ is calculated by the standard deviation of weekly returns for firm *i* in *Down* group over that in *Up* group, n_u and n_d indicate how many weeks are there in year *t* for group *Up* and *Down*, respectively.

$$DUVOL_{i,t} = \ln\left\{(n_u - 1)\sum_{Down} W_{i,\tau}^2 \Big/ (n_d - 1)\sum_{Up} W_{i,\tau}^2\right\} \tag{4}$$

3.3 Empirical models

The following model is estimated to test the impact of participating in emissions trading scheme on crash risk:

$$\begin{aligned} CRASH_{i,t} = {} & \lambda_0 + \lambda_1(ETS_{i,t-1}) + \lambda_2(CRASH_{i,t-1}) + \lambda_3(SIZE_{i,t-1}) + \lambda_4(DTURN_{i,t-1}) \\ & + \lambda_5(MB_{i,t-1}) + \lambda_6(LEV_{i,t-1}) + \lambda_7(ROA_{i,t-1}) + \lambda_8(ABACC_{i,t-1}) \\ & + \lambda_9(RET_{i,t-1}) + \lambda_{10}(SIGMA_{i,t-1}) + Industryfixedeffects + Yearfixedeffects + \varepsilon_{i,t} \end{aligned} \tag{5}$$

Here, $NCSKEW_{i,t}$ and $DUVOL_{i,t}$ are used as dependent variables $CRASH_{i,t}$, and our interested independent variable is an indicator variable ($ETS_{i,t-1}$) which equals one if firm *i* initiates emissions trading in year *t-1*. We include several variables to control for their potential influence on future crash risk in our models. First, in order to control the correlation of *CRASH* in year *t-1*, $NCSKEW_{i,t-1}$ and $DUVOL_{i,t-1}$ are included as control

variables. The natural logarithm of a firm's market value at year *t-1* ($SIZE_{i,t-1}$) is also included to control for firm size due to its predictive power, as noted in previous literature (Chen et al., 2001; Harvey & Siddique, 2000). We also include change in trading volume ($DTURN_{i,t-1}$) in our models, which is obtained by subtracting the mean of share turnover of each month in year *t-1* from that in year *t* for the reason that investors have various opinions (Chen et al., 2001). The market-to-book ratio ($MB_{i,t-1}$) is controlled as stocks with high growth opportunities are related to higher crash risk. The ratio of firm *i*'s total long-term debts over total assets in the previous year ($LEV_{i,t-1}$) is also included in our models along with profitability by using net income over total assets in the previous year ($ROA_{i,t-1}$). Abnormal accrual is also included as a control variable, because the relationship between earnings management and crash risk in the future is positive (Hutton et al., 2009). We measure abnormal accrual as the absolute value of the residual ($ABACC_{i,t-1}$) by following Dechow, Sloan, and Sweeney (1995) and estimate it by running the modified Jones model in each year and each industry. Since higher past returns can build up a bubble that may lead to a large price drop (Chen et al., 2001; Chen, Mehrotra, Sivakumar, & Wayne, 2001), we include it as control variable by using the mean of weekly returns throughout each year ($RET_{i,t-1}$). Finally, stock volatility is controlled by using the standard deviation of the weekly stock returns in each year ($SIGMA_{i\,t-1}$). Industry and year fixed effects are included in all of our

models. We winsorize all the continuous variables at 1st and 99th percentile to mitigate the influence of outliers. Independent and control variables are lagged one year to test the predictability of $ETS_{i,t-1}$ on crash risk in the coming year.

4. Empirical Results

4.1 Descriptive statistics

Table 1 reports the descriptive statistics of crash risk measures along with independent and control variables. $NCSKEW_{i,t}$ and $DUVOL_{i,t}$ of our sample firms are -0.215 and -0.142 on average, respectively. The average firms that participate in emissions trading scheme ($ETS_{i,t-1}$) in our sample is 0.056. The average firm size after taking a natural logarithm of market capitalization ($SIZE_{i,t-1}$) is approximately 24.594. The change in monthly trading volume ($DTURN_{i,t-1}$) is about 0.005 on average. Firms have an average market-to-book ratio ($MB_{i,t-1}$) of 3.041, leverage ($LEV_{i,t-1}$) of 0.123, and profitability ($ROA_{i,t-1}$) of 0.094. The mean of the absolute value of abnormal accruals ($ABACC_{i,t-1}$) is 0.173. The mean value of weekly return in our sample firms ($RET_{i,t-1}$) and volatility ($SIGMA_{i\ t\ -\ 1}$) of our sample firms are -0.1% and 0.040, respectively.

[Insert Table 1 here]

4.2 Correlation matrix

Table 2 reports the correlation matrix for the measures of crash risk, proxy for

participation of emissions trading scheme, and control variables. We find that firms participating in emissions trading scheme ($ETS_{i,t-1}$) is significantly and positively correlated with both $NCSKEW_{i,t}$ and $DUVOL_{i,t}$, indicating that firms that are engaged in green-related activities tend to have higher level of subsequent crash risk. In line with prior literature, $NCSKEW_{i,t}$ correlate with firm size ($SIZE_{i,t-1}$) and the MB ratio ($MB_{i,t-1}$) at the 5% level, implying that firms with larger size and higher growth opportunities re prone to stock crash risk. The positive relationship between $NCSKEW_{i,t}$ and $DUVOL_{i,t}$ and past return ($RET_{i,t-1}$) suggests that firms with higher past returns tend to have crash risk. The multicollinearity concerns that may affect our results are reduced, as noted by the low correlation coefficients between the participation in emissions trading scheme ($ETS_{i,t-1}$) and the control variables.

[Insert Table 2 here]

4.3 The effect of emissions trading scheme participation on crash risk

We test how participation in emissions trading scheme affects future crash risk in this section. Table 3 presents the results. From both columns (1) and (2), $ETS_{i,t-1}$ is positively related with our crash proxies ($NCSKEW_{i,t}$ and $DUVOL_{i,t}$) and the results remain unchanged after including control variables that might affect future stock price crash risk. These results support our hypothesis 1b that managers tend to utilize emissions trading participation as a mask for pursuing self-interests by obfuscating or

concealing negative news from investors and shareholders, leading to subsequent stock price crash risk once the accumulated bad news burst out. An increase in one standard deviation of $ETS_{i,t-1}$ increases $NCSKEW_{i,t}$ by 6% (=0.278 × 0.231/1.066), while it increases $DUVOL_{i,t}$ by 5% (=0.179 × 0.231/0.775), indicating our results are both statistically and economically significant. The coefficients of control variables are generally in line with previous studies (see e.g., Chang, Chen, & Zolotoy, 2017; Kim et al., 2011b; Kim et al., 2014; Yuan, Sun, & Cao, 2016). Larger and more opaque firms with a higher past return are prone to have higher future stock price crash risk.

[Insert Table 3 here]

4.4 Additional analyses

Our main results provide evidence that managers tend to obfuscate negative news by using participation in emissions trading scheme as a mask, resulting in higher probability of experiencing future stock price crash risk. In this subsection we further investigate the mediating effects on the relation between participation in emissions trading scheme and stock price crash risk.

4.4.1 State-owned enterprises

The results shown in Table 4 suggest that state-owned enterprises are less prone to stock price crash risk after participating in emissions trading scheme.

[Insert Table 4 here]

4.4.2 Board independence

In this section we aim to check if internal governance affects our main findings. Specifically, we adopt board independence as proxy for internal governance. Prior studies argue that outside directors might indicate firms' financial transparency (Bushman & Smith, 2003). Following the breakout of financial crisis in the late 1900s, the relationship between corporate governance and corporate transparency has been increasingly critical especially for firms located in Asia (Eng & Mak, 2003; Gul & Leung, 2004). It is believed that directors on board are important in wielding monitoring on top management (Fama & Jensen, 1983). Additionally, one of the critical roles of independent directors is to make sure that top managers do not conduct financial decisions that generated biased cash flows and earnings to benefit themselves and minority shareholders at the expense of interests of all shareholders. Hence, firms with higher proportion of independent directors might attenuate the positive effect of participation in emissions trading scheme on stock price crash risk. The results provided in columns (1) and (3) in Table 5 indicate that firms with higher board independence are more able to exert monitoring on managers, curbing them from obfuscating bad news, leading to lower stock price crash risk in the future.

[Insert Table 5 here]

4.4.3 Board efficiency

Prior literature documents that firms with an even number of board members are more likely to have weak monitoring, because they are found to be associated with a high frequency of financial restatements (Gao & Huang, 2018). Moreover, He and Luo (2018) find that Chinese firms with an even number of board members have more agency problems due to the lack of efficiency in monitoring. As such, firms with an even number of board members have weak monitoring due to inefficiency from the board to reach a consensus when making decisions. We hereby examine the mediating effects of board efficiency on the relation between participation in emissions trading scheme and stock price crash risk. The results are presented in Table 6. $ETS_{i,t-1}$ is found to have a significantly positive relationship with crash measures for firms with an even number of board members based on columns (1) and (3), implying that managers exacerbate the bad news hoarding behavior by exploiting board inefficiency, increasing probability to experience crash risk subsequent to participation in emissions trading scheme.

[Insert Table 6 here]

5. Robustness checks

In this section we conduct several robustness checks by including a number of variables that might potentially affect stock price crash risk in order to reduce issues of related omitted variables and endogeneity concerns.

5.1 Additional controls

Prior literature states that board size (*BdSize*) and proportion of independent directors (*IND*) are related with corporate governance effectiveness (see e.g., Weisbach, 1988; Xu et al., 2014; Yermack, 1996; Yuan et al., 2016), we thus add these potential factors that might affect stock price crash risk in our models. In addition, the extant literature documents that female directors are able to exert higher level of monitoring on managers by requiring more responsibility from managers on poor performance, increasing board meeting attendance, and undertaking monitoring positions on committees (Adams & Ferreira, 2009; Hillman, Shropshire, & Cannella Jr, 2007). Therefore, we add the ratio of female directors to total board members (*FEM*) to our model. Table 7 shows that our primary findings remain unchanged after including the additional variables mentioned above.

[Insert Table 7 here]

5.2 Firm fixed effects

We further add firm fixed effects in order to control for unobserved time invariant heterogeneity. The results are shown in Table 8 and our main findings that firms participating in emissions trading scheme tend to exhibit higher level of stock price risk remain unchanged.

[Insert Table 8 here]

5.3 Two-stage least squares regression

In this section we use another method to alleviate the endogeneity issue by performing two-stage least squares regression. The choice of instrumental variable in performing two-stage least square regression is critical. The instrumental variable should affect the main independent variable, but it cannot influence the dependent variable. We adopt the total carbon dioxide emissions as out instrumental variable since the emissions amount might affect the tendency of participating emissions trading scheme, but not the probability of subsequent stock price crash risk. As presented in Table 9, our primary results remain quantitatively unchanged.

[Insert Table 9 here]

6. Conclusion

This paper examines the effect of emissions trading scheme participation on stock price crash risk. Our primary findings support management obfuscation hypothesis by providing evidence that managers tend to camouflage negative information by using green-related activities as a mask. The main results remain robust after addressing endogeneity issue. Moreover, we find that state-owned enterprises, board independence and efficiency have mediating effects on managers' obfuscation behavior.

Our study provides several contributions as follows. First, we extend management obfuscation hypothesis by documenting a new way of obfuscation. Second, we add more possible but neglected factors that might affect stock price crash risk to the extant literature. Finally, this study provides implications for both policy makers and investors. First, we provide intuition that seemingly environmental friendly activities could be obscure. Second, increased monitoring and internal governance could lower the probability of management obfuscation.

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Appendix

Variable definition.

Variable	Definition
Crash risk proxy	
NCSKEW	The skewness with a negative sign of weekly returns, which are specific to firms for each sample year. See Eq. (3) for details.
DUVOL	The natural logarithm of the standard deviation of weekly returns in the *Down* group over that in the *Up* group. See Eq. (4) for details.
Dummy variable	
ETS	An indicator variable which equals one if firm initiates emissions trading.
Control	
SIZE	The natural logarithm of a firm's market value.
DTURN	The difference between average monthly share turnover in year t and that in the previous year.
MB	The ratio of a firm's market value over its book value.
LEV	Firm *i*'s total long-term debts over total assets.
ROA	Ratio of net income to total assets.
ABACC	The absolute value of the residual by estimating the modified Jones model in each year and industry following Dechow et al. (1995).
RET	Mean of weekly returns specific to firms in each year.
SIGMA	Standard deviation of the weekly returns in year *t*.
Additional controls	
BdSize	The natural logarithm of board total members.
FEM	The ratio of female directors to total board members.
IND	The ratio of independent directors to total board members.

Table 1
Descriptive statistics.

Variable	N	Mean	St. Dev	Q1	Median	Q3
$NCSKEW_{i,t}$	905	-0.215	1.006	-0.805	-0.195	0.441
$DUVOL_{i,t}$	905	-0.142	0.775	-0.679	-0.132	0.340
$ETS_{i,t-1}$	905	0.056	0.231	0.000	0.000	0.000
$NCKSEW_{i,t-1}$	905	-0.205	0.988	-0.791	-0.196	0.411
$DUVOL_{i,t-1}$	905	-0.154	0.779	-0.682	-0.143	0.339
$SIZE_{i,t-1}$	905	24.594	0.986	23.990	24.493	25.125
$DTURN_{i,t-1}$	905	0.005	0.099	-0.023	0.000	0.029
$MB_{i,t-1}$	905	3.041	3.919	1.271	1.883	3.227
$LEV_{i,t-1}$	905	0.123	0.123	0.015	0.093	0.196
$ROA_{i,t-1}$	905	0.094	0.244	0.022	0.044	0.090
$ABACC_{i,t-1}$	905	0.173	0.527	0.024	0.057	0.127
$RET_{i,t-1}$	905	-0.001	0.005	-0.005	-0.002	0.002
$SIGMA_{i,t-1}$	905	0.040	0.015	0.029	0.038	0.048

Notes: This table reports the descriptive statistics of crash risk proxies along with proxy for participating in emissions trading scheme and control variables during the period 2008-2020. Variables are defined in Appendix.

Table 2
Correlation matrix.

	(1)	(2)	(3)	(4)	(5)	(6)
(1) $NCSKEW_{i,t}$	1.000					
(2) $DUVOl_{i,t}$	0.921***	1.000				
(3) $ETS_{i,t-1}$	0.066**	0.057*	1.000			
(4) $NCSKEW_{i,t-1}$	0.078**	0.096***	-0.008	1.000		
(5) $DUVOl_{i,t-1}$	0.052	0.075**	-0.013	0.927***	1.000	
(6) $SIZE_{i,t-1}$	0.067**	0.050	0.237***	-0.101***	-0.148***	1.000
(7) $DTURN_{i,t-1}$	-0.026	-0.039	-0.015	-0.207***	-0.198***	-0.004
(8) $MB_{i,t-1}$	0.070**	0.037	-0.082**	-0.049	-0.085**	0.067**
(9) $LEV_{i,t-1}$	-0.067**	-0.049	0.122***	-0.066**	-0.061*	0.059*
(10) $ROA_{i,t-1}$	0.027	0.005	-0.048	-0.007	-0.031	-0.060*
(11) $ABACC_{i,t-1}$	0.041	0.042	-0.055*	0.045	0.040	-0.067**
(12) $RET_{i,t-1}$	0.079**	0.063*	0.023	-0.593***	-0.709***	0.213***
(13) $SIGMA_{i,t-1}$	0.019	-0.015	-0.059*	-0.218***	-0.265***	-0.057*

	(7)	(8)	(9)	(10)	(11)	(12)	(13)
(7) $DTURN_{i,t-1}$	1.000						
(8) $MB_{i,t-1}$	0.048	1.000					
(9) $LEV_{i,t-1}$	-0.032	-0.230***	1.000				
(10) $ROA_{i,t-1}$	-0.056*	0.013	-0.179***	1.000			
(11) $ABACC_{i,t-1}$	-0.006	0.010	-0.084**	0.808***	1.000		
(12) $RET_{i,t-1}$	0.139***	0.175***	-0.031	0.071**	-0.024	1.000	
(13) $SIGMA_{i,t-1}$	0.397***	0.134***	-0.049	0.035	-0.000	0.196***	1.000

Notes: This table reports the correlation matrix of crash risk proxies along with proxy for participating in emissions trading scheme and control variables during the period 2008-2020. Variables are defined in Appendix.

Table 3
Emissions trading on stock price crash risk.

Dependent Variables:	$NCSKEW_{i,t}$		$DUVOL_{i,t}$	
	(1)	(2)	(3)	(4)
$ETS_{i,t-1}$	0.335**	0.278**	0.231**	0.179*
	(2.54)	(2.09)	(2.40)	(1.91)
$NCSKEW_{i,t-1}$		0.135***		
		(2.96)		
$DUVOl_{i,t-1}$				0.171***
				(3.39)
$SIZE_{i,t-1}$		0.059*		0.043*
		(1.84)		(1.73)
$DTURN_{i,t-1}$		-0.298		-0.330
		(-0.78)		(-1.05)
$MB_{i,t-1}$		0.009		0.002
		(1.25)		(0.34)
$LEV_{i,t-1}$		-0.552*		-0.348
		(-1.89)		(-1.56)
$ROA_{i,t-1}$		-0.259		-0.288*
		(-1.41)		(-1.92)
$ABACC_{i,t-1}$		0.197**		0.168**
		(2.18)		(2.44)
$RET_{i,t-1}$		19.410***		22.492***
		(2.72)		(3.39)
$SIGMA_{i,t-1}$		3.541		1.847
		(1.27)		(0.91)
Constant	0.672***	-0.631	0.135	-0.686
	(3.46)	(-0.75)	(0.87)	(-1.05)
Industry fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Adjusted R-squared	0.076	0.094	0.053	0.072
Number of observations	910	905	910	905

Notes: This table reports results that examine the effects from participation in emissions trading scheme on crash risk using OLS regression. The dependent variable in columns (1) and (2) is $NCSKEW_{i,t}$, defined as the skewness with a negative sign of weekly returns that are specific to firms. The dependent variable in columns (3) and (4) is $DUVOL_{i,t}$, defined as the natural logarithm of the standard deviation of weekly returns in the *Down* group over that in the *Up* group. $ETS_{i,t-1}$ an indicator variable which equals one if firm *i* initiates emissions trading in year *t-1*. Variables are defined in Appendix. The t-statistic based on the standard error clustered at firm level of each coefficient is provided in parentheses. We include industry and year fixed effects in all the models. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 4
Additional analysis: State owned enterprises.

Dependent Variables:	$NCSKEW_{i,t}$		$DUVOL_{i,t}$	
	State owned enterprises			
	(1) Yes	(2) No	(3) Yes	(4) No
$ETS_{i,t-1}$	0.030	0.530***	0.068	0.295*
	(0.10)	(2.75)	(0.33)	(1.96)
$NCSKEW_{i,t-1}$	0.132	0.100*		
	(1.66)	(1.72)		
$DUVOl_{i,t-1}$			0.191*	0.171***
			(1.92)	(2.68)
$SIZE_{i,t-1}$	0.066	0.007	0.032	0.017
	(1.19)	(0.12)	(0.68)	(0.37)
$DTURN_{i,t-1}$	-2.098**	0.118	-1.760**	0.048
	(-2.10)	(0.27)	(-2.20)	(0.13)
$MB_{i,t-1}$	-0.030	0.008	-0.033	0.004
	(-0.76)	(0.99)	(-1.05)	(0.62)
$LEV_{i,t-1}$	0.216	-0.384	0.166	-0.015
	(0.31)	(-0.75)	(0.32)	(-0.04)
$ROA_{i,t-1}$	-0.397	0.494	-0.494**	0.313
	(-1.50)	(1.10)	(-2.19)	(0.97)
$ABACC_{i,t-1}$	-0.080	-0.111	0.082	-0.074
	(-0.36)	(-0.55)	(0.40)	(-0.50)
$RET_{i,t-1}$	23.445	23.270***	32.921*	24.187***
	(1.24)	(2.87)	(1.89)	(3.15)
$SIGMA_{i,t-1}$	4.553	2.931	3.095	1.345
	(0.81)	(0.87)	(0.75)	(0.57)
Constant	-3.132**	0.736	-1.984*	-0.254
	(-2.23)	(0.51)	(-1.68)	(-0.23)
Industry fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Adjusted R-squared	0.090	0.118	0.099	0.085
Number of observations	277	500	277	500

Notes: This table reports results that examine the effects from participation in emissions trading scheme on crash risk using OLS regression. The dependent variable in columns (1) and (2) is $NCSKEW_{i,t}$, defined as the skewness with a negative sign of weekly returns that are specific to firms. The dependent variable in columns (3) and (4) is $DUVOL_{i,t}$, defined as the natural logarithm of the standard deviation of weekly returns in the *Down* group over that in the *Up* group. $ETS_{i,t-1}$ an indicator variable which equals one if firm *i* initiates emissions trading in year *t-1*. State owned enterprises are defined by whether the firms are controlled by government or not. Variables are defined in Appendix. The t-statistic based on the standard error clustered at firm level of each coefficient is provided in parentheses. We include industry and year fixed effects in all the models. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 5
Additional analysis: Board independence.

Dependent Variables:	$NCSKEW_{i,t}$		$DUVOL_{i,t}$	
	Board independence			
	(1) High	(2) Low	(3) High	(4) Low
$ETS_{i,t-1}$	0.087	0.643**	0.082	0.459*
	(0.39)	(2.11)	(0.50)	(1.69)
$NCSKEW_{i,t-1}$	0.176***	0.010		
	(2.75)	(0.14)		
$DUVOl_{i,t-1}$			0.213***	0.086
			(2.90)	(1.03)
$SIZE_{i,t-1}$	0.029	0.145**	0.024	0.111**
	(0.65)	(2.50)	(0.70)	(2.16)
$DTURN_{i,t-1}$	-0.390	-0.228	-0.302	-0.318
	(-0.73)	(-0.38)	(-0.67)	(-0.58)
$MB_{i,t-1}$	0.012*	-0.012	0.005	-0.018
	(1.91)	(-0.62)	(1.03)	(-1.17)
$LEV_{i,t-1}$	-0.002	-1.331*	0.146	-1.062**
	(-0.00)	(-1.98)	(0.46)	(-2.10)
$ROA_{i,t-1}$	-0.013	-1.108***	-0.074	-0.849***
	(-0.07)	(-4.24)	(-0.44)	(-3.77)
$ABACC_{i,t-1}$	0.119	0.179	0.091	0.217*
	(1.22)	(1.33)	(1.13)	(1.74)
$RET_{i,t-1}$	24.119***	9.254	27.253***	15.382
	(2.75)	(0.71)	(3.21)	(1.30)
$SIGMA_{i,t-1}$	2.665	3.491	0.015	4.042
	(0.79)	(0.64)	(0.01)	(0.96)
Constant	-0.920	-4.296***	-0.716	-3.243**
	(-0.88)	(-2.98)	(-0.89)	(-2.50)
Industry fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Adjusted R-squared	0.058	0.168	0.046	0.119
Number of observations	576	293	576	293

Notes: This table reports results that examine the effects from participation in emissions trading scheme on crash risk using OLS regression. The dependent variable in columns (1) and (2) is $NCSKEW_{i,t}$, defined as the skewness with a negative sign of weekly returns that are specific to firms. The dependent variable in columns (3) and (4) is $DUVOL_{i,t}$, defined as the natural logarithm of the standard deviation of weekly returns in the *Down* group over that in the *Up* group. $ETS_{i,t-1}$ an indicator variable which equals one if firm *i* initiates emissions trading in year *t-1*. Firms with high (low) board independence is defined by whether the independent director proportion is higher (lower) than the sample median. Variables are defined in Appendix. The t-statistic based on the standard error clustered at firm level of each coefficient is provided in parentheses. We include industry and year fixed effects in all the models. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 6
Additional analysis: Even number of directors.

Dependent Variables:	$NCSKEW_{i,t}$		$DUVOL_{i,t}$	
	Even number of directors			
	(1) Yes	(2) No	(3) Yes	(4) No
$ETS_{i,t-1}$	0.409**	0.027	0.272*	0.074
	(2.11)	(0.15)	(1.75)	(0.53)
$NCSKEW_{i,t-1}$	0.140*	0.112*		
	(1.77)	(1.77)		
$DUVOl_{i,t-1}$			0.270***	0.133**
			(2.67)	(2.03)
$SIZE_{i,t-1}$	0.061	0.053	0.011	0.044
	(0.92)	(1.23)	(0.23)	(1.24)
$DTURN_{i,t-1}$	-0.209	-0.302	-0.367	-0.219
	(-0.28)	(-0.65)	(-0.53)	(-0.60)
$MB_{i,t-1}$	-0.003	0.012*	-0.011	0.007
	(-0.21)	(1.75)	(-0.98)	(1.14)
$LEV_{i,t-1}$	0.165	-0.485	0.184	-0.325
	(0.37)	(-1.18)	(0.51)	(-0.98)
$ROA_{i,t-1}$	-0.383*	-0.035	-0.393**	-0.118
	(-1.80)	(-0.13)	(-1.99)	(-0.50)
$ABACC_{i,t-1}$	0.140	0.119	0.094	0.120
	(1.43)	(0.92)	(1.20)	(1.05)
$RET_{i,t-1}$	38.747***	9.948	51.980***	9.131
	(2.96)	(1.08)	(4.21)	(1.08)
$SIGMA_{i,t-1}$	1.585	3.188	0.913	1.221
	(0.29)	(0.88)	(0.23)	(0.46)
Constant	-1.076	-1.281	0.112	-0.775
	(-0.65)	(-1.20)	(0.09)	(-0.87)
Industry fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Adjusted R-squared	0.109	0.092	0.113	0.056
Number of observations	278	591	278	591

Notes: This table reports results that examine the effects from participation in emissions trading scheme on crash risk using OLS regression. The dependent variable in columns (1) and (2) is $NCSKEW_{i,t}$, defined as the skewness with a negative sign of weekly returns that are specific to firms. The dependent variable in columns (3) and (4) is $DUVOL_{i,t}$, defined as the natural logarithm of the standard deviation of weekly returns in the *Down* group over that in the *Up* group. $ETS_{i,t-1}$ an indicator variable which equals one if firm *i* initiates emissions trading in year *t-1*. Firms with even number of directors is defined by whether the total number of board directors is even or not. Variables are defined in Appendix. The t-statistic based on the standard error clustered at firm level of each coefficient is provided in parentheses. We include industry and year fixed effects in all the models. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 7
Additional controls.

Dependent Variables:	$NCSKEW_{i,t}$			$DUVOL_{i,t}$		
	(1)	(2)	(3)	(4)	(5)	(6)
$ETS_{i,t-1}$	0.279*	0.279*	0.286*	0.195*	0.195*	0.201*
	(1.89)	(1.89)	(1.91)	(1.76)	(1.75)	(1.78)
$NCSKEW_{i,t-1}$	0.134***	0.134***	0.134***			
	(2.84)	(2.83)	(2.84)			
$DUVOl_{i,t-1}$				0.174***	0.174***	0.174***
				(3.31)	(3.30)	(3.31)
$SIZE_{i,t-1}$	0.059*	0.059*	0.065*	0.042*	0.042*	0.046*
	(1.89)	(1.87)	(1.95)	(1.67)	(1.67)	(1.76)
$DTURN_{i,t-1}$	-0.283	-0.284	-0.278	-0.283	-0.282	-0.278
	(-0.74)	(-0.74)	(-0.73)	(-0.91)	(-0.90)	(-0.89)
$MB_{i,t-1}$	0.007	0.007	0.007	0.001	0.001	0.001
	(1.03)	(1.02)	(0.89)	(0.20)	(0.21)	(0.12)
$LEV_{i,t-1}$	-0.401	-0.401	-0.400	-0.254	-0.255	-0.254
	(-1.30)	(-1.29)	(-1.31)	(-1.03)	(-1.03)	(-1.04)
$ROA_{i,t-1}$	-0.224	-0.224	-0.218	-0.244*	-0.245*	-0.241*
	(-1.29)	(-1.29)	(-1.26)	(-1.67)	(-1.68)	(-1.65)
$ABACC_{i,t-1}$	0.180**	0.180**	0.173**	0.147**	0.148**	0.143**
	(2.07)	(2.05)	(1.98)	(2.15)	(2.14)	(2.07)
$RET_{i,t-1}$	18.579**	18.592**	18.333**	21.971***	21.912***	21.762***
	(2.49)	(2.46)	(2.41)	(3.17)	(3.13)	(3.10)
$SIGMA_{i,t-1}$	3.238	3.237	3.274	1.503	1.506	1.536
	(1.09)	(1.09)	(1.10)	(0.69)	(0.70)	(0.71)
$BdSize_{i,t-1}$	-0.218	-0.218	-0.273*	-0.145	-0.144	-0.185
	(-1.55)	(-1.55)	(-1.77)	(-1.32)	(-1.31)	(-1.54)
$FEM_{i,t-1}$		-0.008	-0.042		0.029	0.004
		(-0.03)	(-0.14)		(0.13)	(0.02)
$IND_{i,i-1}$			-0.589			-0.437
			(-1.23)			(-1.21)
Constant	-1.515*	-1.512*	-1.283	-1.330**	-1.344**	-1.174*
	(-1.85)	(-1.77)	(-1.48)	(-2.02)	(-1.98)	(-1.69)
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared	0.094	0.092	0.093	0.072	0.071	0.071
Number of observations	865	865	865	865	865	865

Notes: This table reports results examine the effects from participation in emissions trading scheme on crash risk using OLS regression. The dependent variable in columns (1) to (3) is *NCSKEW*, defined as the skewness with a negative sign of weekly returns that are specific to firms. The dependent variable in columns (4) to (6) is *DUVOL*, defined as the natural logarithm of the standard deviation of weekly returns in the Down group over that in the Up group. $ETS_{i,t-1}$ an indicator variable which equals one if firm *i* initiates emissions trading in year *t-1*. $BdSize_{i,t-1}$ is the natural logarithm of board total members. $FEM_{i,t-1}$ is the ratio of female directors to total board members of firm *i* in year *t-1*. $IND_{i,t-1}$ is the ratio of independent directors to total board members of firm *i* in year *T-1*. Variables are defined in Appendix. The t-statistic based on the standard error clustered at firm level of each coefficient is provided in parentheses. We include industry and year fixed effects in all the models. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 8
Firm fixed effects.

Dependent Variables:	$NCSKEW_{i,t}$		$DUVOL_{i,t}$	
	(1)	(2)	(3)	(4)
$ETS_{i,t-1}$	0.527*	0.488*	0.428**	0.388*
	(1.85)	(1.70)	(2.14)	(1.88)
$NCSKEW_{i,t-1}$		0.002		
		(0.03)		
$DUVOl_{i,t-1}$				0.063
				(0.83)
$SIZE_{i,t-1}$		0.879***		0.759***
		(5.50)		(6.18)
$DTURN_{i,t-1}$		-0.302		-0.450
		(-0.56)		(-1.05)
$MB_{i,t-1}$		-0.020		-0.027
		(-0.72)		(-1.41)
$LEV_{i,t-1}$		-0.972		-0.790
		(-1.32)		(-1.44)
$ROA_{i,t-1}$		-0.515*		-0.538***
		(-1.70)		(-2.79)
$ABACC_{i,t-1}$		0.119		0.082
		(0.89)		(0.78)
$RET_{i,t-1}$		4.138		14.226
		(0.41)		(1.42)
$SIGMA_{i,t-1}$		-3.415		-3.090
		(-0.77)		(-0.93)
Constant	-1.345***	-21.012***	-1.194***	-18.202***
	(-3.91)	(-5.54)	(-3.28)	(-6.11)
Firm fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Adjusted R-squared	0.058	0.124	0.010	0.106
Number of observations	910	905	910	905

Notes: This table reports results that examine the effects from participation in emissions trading scheme on crash risk using OLS regression. The dependent variable in columns (1) and (2) is $NCSKEW_{i,t}$, defined as the skewness with a negative sign of weekly returns that are specific to firms. The dependent variable in columns (3) and (4) is $DUVOL_{i,t}$, defined as the natural logarithm of the standard deviation of weekly returns in the *Down* group over that in the *Up* group. $ETS_{i,t-1}$ an indicator variable which equals one if firm *i* initiates emissions trading in year *t-1*. Variables are defined in Appendix. The t-statistic based on the standard error clustered at firm level of each coefficient is provided in parentheses. We include firm and year fixed effects in all the models. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 9
2SLS regression.

Dependent Variables:	$NCSKEW_{i,t}$		$DUVOL_{i,t}$	
	(1)	(2)	(3)	(4)
$ETS_{i,t-1}$	1.320**	1.218*	1.271***	1.165**
	(2.25)	(1.72)	(2.71)	(2.07)
$NCSKEW_{i,t-1}$		0.132***		
		(2.94)		
$DUVOl_{i,t-1}$				0.163***
				(3.14)
$SIZE_{i,t-1}$		0.005		-0.014
		(0.09)		(-0.32)
$DTURN_{i,t-1}$		-0.340		-0.374
		(-0.82)		(-1.14)
$MB_{i,t-1}$		0.010		0.003
		(1.06)		(0.44)
$LEV_{i,t-1}$		-0.603*		-0.404
		(-1.79)		(-1.51)
$ROA_{i,t-1}$		-0.273		-0.303
		(-1.08)		(-1.51)
$ABACC_{i,t-1}$		0.201*		0.172*
		(1.69)		(1.83)
$RET_{i,t-1}$		20.039**		22.699***
		(2.38)		(3.00)
$SIGMA_{i,t-1}$		3.721		2.007
		(1.33)		(0.90)
Constant	-1.092	-1.081	-1.235	-0.600
	(-0.94)	(-0.78)	(-1.34)	(-0.55)
Firm fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
R-squared	0.064	0.097	0.004	0.043
Number of observations	910	905	910	905

Notes: This table reports results that examine the effects from participation in emissions trading scheme on crash risk using two-stage least squares regression. The dependent variable in columns (1) and (2) is $NCSKEW_{i,t}$, defined as the skewness with a negative sign of weekly returns that are specific to firms. The dependent variable in columns (3) and (4) is $DUVOL_{i,t}$, defined as the natural logarithm of the standard deviation of weekly returns in the *Down* group over that in the *Up* group. $ETS_{i,t-1}$ an indicator variable which equals one if firm *i* initiates emissions trading in year *t-1*. The total carbon dioxide emissions is adopted as the instrumental variable. Variables are defined in Appendix. The t-statistic based on the standard error clustered at firm level of each coefficient is provided in parentheses. We include industry and year fixed effects in all the models. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.