Original Research

Voluntary Environmental Regulation and Stock Price Crash Risk: Moderating Role of Media Attention

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Abstract

With the increasing attention to environmental protection, flexible voluntary environmental regulation has aroused extensive discussion. Using the 3432 Chinese A-share listed companies as research samples from 2008 to 2020, we explore the relationship between voluntary environmental regulation and the risk of the stock price crash, and the moderating effect of media attention. We find that voluntary environmental regulation can effectively reduce stock price crash risk, which supports the Porter hypothesis. The media attention further enhances the negative relationship between voluntary environmental regulation and stock price crash risk. We further consider the nature of corporate property rights and find that voluntary environmental regulation can better help state-owned companies reduce stock price crash risk, while the impact on non-state companies is not significant. In addition, we divide the media attention into positive and negative categories, and the results show that both positive and negative media attention positively mediate the negative relationship between voluntary environmental regulation and stock price crash risk. Our conclusions confirm the Porter hypothesis and provide some implications for policymakers to optimize environmental regulation.

Keywords: voluntary environmental regulation, stock price crash risk, media attention, corporate property rights

Introduction

As the largest developing country in the world, China has made remarkable efforts in environmental protection. In 2021, 64.3% of 339 prefecture-level and larger cities in China met air quality standards, which is 3.5% higher than that in 2020 [1]. In addition, the punishment for environmental violations has become increasingly strict. Chinese environmental protection departments issued 132800 administrative punishment decisions with a fine of 11.687 billion yuan in 2021 [1]. Therefore, the potential damage to corporate reputation caused by environmental misconduct is more serious than ever before [2-4], and these damages threaten the legitimacy of companies [5]. Stakeholders pay more attention to corporate environmental practices and exert pressure on the company to meet social expectations and environmental standards [6, 7]. Suppose the company only complies with the mandatory environmental

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regulations implemented by the government, which may lead the company to fail to meet the new requirements when the regulations change. It would also be difficult to become an environmental leader to gain a competitive advantage. Therefore, many companies choose to participate in voluntary environmental regulation with higher flexibility rather than command-and-control, which controls pollution by providing incentives and usually has a higher standard than mandatory environmental regulation [8-10]. Companies participating in voluntary environmental regulation will send a signal of environmental protection efforts to external stakeholders [11]. Thus, it helps companies gain reputation and benefits by attracting stakeholders as environmental leaders [12].

According to the Porter hypothesis, more stringent but properly designed environmental regulation is an external pressure to improve organizational inertia, enhancing firms' competitiveness by stimulating innovation, and promoting a win-win situation for the ecological environment and the economy [13, 14]. Voluntary environmental regulation just meets the characters of the Porter hypothesis. Previous studies also discuss the benefits of voluntary environmental regulation from the perspectives of pollutant emission reduction [15], innovation [10], investment [16], performance [17], and productivity [18]. Although voluntary environmental regulation has many advantages, many studies propose that it is not a panacea for solving environmental problems. Krut & Gleckman (2013) believe that voluntary environmental regulation did not measure the company's actual environmental performance and could not promote the sustainable development of companies [19]. Voluntary environmental regulation may also be ineffective in reducing pollutant emissions and improving the energy investment structure [20]. It may even damage the company's green innovation efficiency [21].

The stock price crash risk will severely impact the capital market, which has attracted wide attention in the academic circle [22-24]. Therefore, it is increasingly important for policymakers and investors to explore the relationship between voluntary environmental regulation and stock price crash risk. Literature finds that many factors could affect stock price crash risk, including opaque financial reports [25], CEO overconfidence [26], stock liquidity [27], accounting conservatism [28], information transparency [29], corporate tax avoidance [30], gambling preference [31] and ecological innovation [32]. However, few scholars investigate the relationship between environmental regulation and stock price crash risk. Voluntary environmental regulation may reduce the information opacity by disclosing more information about the company's environment, thereby reducing stock price crash risk. Nevertheless, it may also help the company withhold negative news, leading to hoarding negative news and increasing stock price crash risk. Therefore, this paper tries to discuss the relationship

between voluntary environmental regulation and stock price crash risk.

In recent years, the propagation speed and breadth of information have greatly improved since technology's progress. The media is increasingly important in promoting social development [33]. The media plays a vital role in transmitting the company's environmental information and supervising the company's environmental behavior. At the same time, investor sentiment could be affected by media reports, which significantly change investors' trading decisions [34, 35]. This effect is also asymmetrical, with investors more likely to ignore negative information in rising markets and more likely to ignore positive news in falling markets [35]. As investors are more sensitive to negative news, it will cause severe adverse reactions [36]. Therefore, media attention may not only prevent the hoarding of negative news, thus reducing the risk of the stock price crash [37], but may promote the dissemination of information and enhance the negative reaction of investors. Therefore, it is important to explore the moderating effect of media attention on the relationship between voluntary environmental regulation and stock price crash risk.

The contributions of this paper are as follows: First, we explore the relationship between voluntary environmental regulation and stock price crash risk. This links the Porter hypothesis to stock price crash risk and provides confidence for corporate managers to actively participate in environmental protection activities. Secondly, we analyze the moderating effect of media attention between voluntary environmental regulation and stock price crash risk, linking the Porter hypothesis and media attention. Third, we divide media attention into positive and negative dimensions for discussion, which provides an empirical basis for policymakers to implement and strengthen the role of media supervision.

Material and Methods

Hypotheses Development

The Porter Hypothesis

Environmental regulation and firm performance are seen as irreconcilable contradictions for a long time. There are a large number of scholars who have discussed this issue and formed two major views [38]. Under the traditional view, environmental regulations (e.g. emission restriction, tax on environmental production) may produce additional costs to the firm operation, undermining the firm competitiveness [39]. Under the alternative view, Porter hypothesis in the 1990s argue that more stringent but properly designed environmental regulations could stimulate innovation, and the innovation may fully offset the cost in some instances [13, 14]. Therefore, the

firms seeking for better performance, will invest more in environment-friendly innovation. Environmental ecology and economy will achieve a win-win situation.

Voluntary Environmental Regulation and Stock Price Crash Risk

The stock price crash risk refers to the possibility of a sudden and large-scale decline company's stock price, which is mainly caused by managers withholding negative news from external investors [40] or the information asymmetry [41]. According to the agency theory, the separation of ownership and control rights of modern companies has resulted in a conflict of interest between shareholders and management, which is the agency problem [42]. One manifestation of agency conflict is the misalignment between managers' information disclosure preferences and those of shareholders, leading managers to tend to withhold negative news [43]. Managers' motives for withholding negative news include protecting their careers [41], obtaining incentive compensation based on firm performance [44], and facilitating their rent-seek behavior [30]. However, negative news cannot be withheld forever. When the cost of withholding bad news is greater than the associated benefits, the accumulated bad news will likely be disclosed simultaneously [40]. Jin & Myers (2006) believe that the characteristics of stock market returns depend on how information is released [29]. If the management timely and reliably reports all information and eliminates the opacity, stock price crash risk will not be significantly affected; if the news is withheld until the difference between the intrinsic value of the company and the stock price reaches a critical value, then the news is released all at once, it will have a huge impact on the stock return. Therefore, if the manager withholds negative news, the one-time release of information will cause a sharp drop in the stock price. It is widespread for corporate managers to choose to delay the release of bad news for short-term benefits [45].

We believe that voluntary environmental regulation can effectively reduce stock price crash risk. Because voluntary environmental regulation encourages companies to prepare environmental statements [46], which prevents the manager from hoarding negative environmental information and helps companies reduce information asymmetry between themselves and investors. Meanwhile, when the environmental influence of the company is highly opaque, the company participates in voluntary environmental regulation, helping signal environmental protection efforts to external stakeholders [11]. Thus, voluntary environmental regulation improves the image of the company and improves the relationship with all stakeholders, helping the company gain reputation [47, 48]. Finally, active participation in voluntary environmental regulation reflects that the company has a good corporate social responsibility. Corporate social responsibility can produce protection similar to insurance for the company. It can accumulate moral capital among stakeholders, thus reducing the negative reaction of stakeholders to adverse events [49, 50]. Therefore, participation in voluntary environmental regulation reduces stock price crash risk by reducing information asymmetry, helping companies establish reputation and insurance effects. Based on the above views, we propose research Hypothesis 1:

Hypothesis 1: Voluntary environmental regulation reduces stock price crash risk.

Voluntary Environmental Regulation, Media Coverage, and Stock Price Crash Risk

We believe that media attention can enhance the negative relationship between voluntary environmental regulation and stock price crash risk. First, media attention plays an important role in the information effect and discipline effect, reducing the tendency of company managers to withhold negative news [37]. This helps show the actual impact of voluntary environmental regulation on the company to investors (including financial costs and actual environmental performance) and avoid management hoarding of negative news. Secondly, media attention has increased companies' exposure, making investors more aware of the company's efforts on environmental protection. Corporate increases information transparency and corporate social responsibility can help reduce stock price crash risk [41, 51]. Therefore, media attention further enhances the negative relationship between voluntary environmental regulation and stock price crash risk by improving information transparency and demonstrating responsible corporate behavior. Therefore, we propose research Hypothesis 2:

Hypothesis 2: Media attention enhances the negative relationship between voluntary environmental regulation and stock price crash.

Sample and Data

Sample

To explore the effect of voluntary environmental regulation on stock price crash risk, and the moderating effect of media attention, by using the ordinary least squares (OLS) estimates. The model is constructed as follows:

Main effect model:

$$NCSKEW_{i,t+1} = \beta_0 + \beta_1 ISO_{i,t} + \beta_2 Controls_{i,t} + \sum Year + \sum Industry + \varepsilon_{i,t} \tag{1}$$

Moderating effect model:

$$NCSKEW_{i,t+1} = \beta_0 + \beta_1 ISO_{i,t} + \beta_2 Media_{i,t}$$
$$+ \beta_3 ISO \times Media_{i,t} + \beta_4 Controls_{i,t}$$
$$+ \sum Year + \sum Industry + \varepsilon_{i,t} \quad (2)$$

The subscriptions i and t represent the data of the ith company in year t, respectively; $NCSKEW$ means stock price crash risk; ISO is voluntary environmental regulation; $Media$ is media attention; $Controls$ represents a set of control variables, including stock turnover ($Turnover$); Market Return (RET); Market volatility ($SIGMA$); Earnings Management (DA); Number of analysts followed ($ANALYST$); Company size ($SIZE$); Firm leverage (LEV); Return on total assets (ROA); Market to book ratio (MB); Growth rate ($GROWTH$). We also include dummy variables of year and industry in the model. ε is an error item.

Measurement of Variables

1. Explained variable. The explained variable in the empirical research of this paper is stock price crash risk. Following scholars [52, 53], we use the negative coefficient of skewness as the mesurement of company's stock price crash risk ($NCSKEW$). The calculation method is as follows:

First, we estimate firm-specific weekly returns for each firm (W):

$$r_{i,n} = \alpha_i + \alpha_{1,i} r_{m,n-2} + \alpha_{2,i} r_{m,n-1} + \alpha_{3,i} r_{m,n}$$
$$+ \alpha_{4,i} r_{m,n+1} + \alpha_{5,i} r_{m,n+2} + \varepsilon_{i,n} \quad (3)$$

Where $\varepsilon_{i,n}$ is the residual term of the model (3), which represents the part of the stock price that the market cannot explain. In order to make the residual term obey the standard normal distribution, we plus 1 to the residual and take the natural logarithm to obtain the company's special weekly rate of return ($W_{i,n}$, $W_{i,n} = ln(1 + \varepsilon_{i,n})$).

Second, the negative coefficient of skewness ($NCSKEW$) is calculated using the company-specific weekly rate of return ($W_{i,n}$). The calculation method is as follows:

$$NCSKEW_{i,t} = \left[-N(N-1)\sum W_{i,t}^3\right] \Big/ \left[(N-1)(N-2)\left(\sum W_{i,t}^2\right)^{\frac{3}{2}}\right] \quad (4)$$

In formula (4), N is the number of trading weeks of company stock i in year t. $NCSKEW$ represents stock price crash risk. The greater the value, the greater the risk of the stock price crash, and vice versa.

2. Explanatory variables. We use voluntary environmental regulation as an explanatory variable, which is measured by whether the company has passed the ISO14001 environmental management standard certification. ISO14001 Environmental Management Standard, initiated by the International Organization for Standardization (ISO) in 1996, which is a series of voluntary international standards that include environmental management systems, environmental auditing, environmental labeling, life cycle assessment, enterprise environmental behavior assessment, and environmental impact of products. It drives organizations to improve their environmental performance by using resources more effectively and reducing waste [54]. Therefore, following the research of scholars [10, 55], we select the dummy variable (ISO) as the proxy variable of voluntary environmental regulation. If the company has passed the ISO14001 certification in a given year, the ISO value is 1, otherwise is 0.

3. Moderating variable. To explore the moderating effect of media attention on the relationship between voluntary environmental regulation and stock price crash risk, we select the number of companies reported by the media ($Media$) as measurement of moderating variable, referring to scholars [56, 57]. Since the number of media attention is discrete data, we take the logarithm of the data. The calculation method is as follows:

$$Media_{i,t} = \ln\left(Number\ of\ media\ reports + 1\right) \quad (5)$$

4. Control variables. To control the Omitted variable bias caused by differences between individual companies, following scholars [37, 57], we incorporate the following firm-level control variables into the models. Stock turnover rate ($TURNOVER$), which controls the stock liquidity. Market return (RET), which controls the performance of stocks. The standard deviation of stock returns ($SIGMA$), which controls stock volatility; DA controls the level of earnings management. The number of analysts ($ANALYST$), which controls the degree of analysts' attention to the company. The size of assets ($SIZE$), which is defined as the natural logarithm companies' total assets, and this variable controls the effect of firm size on the explained variable. The ratio of total liabilities to total assets (LEV), which measures companies' asset structure. The ratio of net profit to total assets (ROA) control companies' financial performance. MB is markets' expectation of the company. $GROWTH$ is the growth rate of the main business revenue. Table 1 reports the specific definitions and data sources of the variables involved in our model.

Data

Our sample data includes all A-share listed companies from 2008 to 2020. Our stock price collapse risk and voluntary environmental regulation data are from China Stock Market and Accounting Research (CSMAR) database; Media attention data comes from Chinese Research Data Services (CNRDS) database; other control variables are from the CSMAR database.

Table 1. Variables definition.

Variable	Definition	Data source
Interpreted variable:		
NCSKEW	Stock price crash risk. Measured by the negative coefficient of skewness.	CSMAR
Explanatory variables:		
ISO	Voluntary environmental regulation. Dummy variable, if company has passed the ISO14001 environmental management standard certification the value is 1; otherwise, it is 0.	CSMAR
Media	Media attention. The natural logarithm of the number of companies reported by the media.	CSMAR
TURNOVER	The monthly average excess turnover of stocks.	CSMAR
RET	The annual average weekly particular yield of stock (%).	CSMAR
SIGMA	The standard deviation of annual and weekly special return rate of stock (%).	CSMAR
DA	Absolute firm' accrued earnings management.	CSMAR
ANALYST	The natural logarithm of the number of company analysts tracking.	CSMAR
SIZE	The natural logarithm of the total assets of the company.	CSMAR
LEV	The proportion of total liabilities to total assets.	CSMAR
ROA	The proportion of net profit in total assets.	CSMAR
MB	Book value ratio of companies.	CSMAR
GROWTH	The growth rate of primary business income.	CSMAR

After excluding (1) companies with abnormal financial conditions (ST, ST *); (2) Companies in the financial industry; (3) Companies are lacking risk data of stock price crash; (4) Companies lacking voluntary environmental regulation data; (5) For companies lacking control variables, our research sample includes the unbalanced panel data of 26927 annual observations of 3432 companies from 2008 to 2020.

Descriptive Statistics

Table 2 shows the descriptive statistics for all variables used in this research. We find that the mean value of stock price crash risk (*NCSKEW*) is -0.300, and the standard deviation is 0.698. Regarding the explanatory variables (*ISO*), the mean value is 0.203, which means that 20.3% of the firm participates

Table 2. Descriptive statistics.

Variable	Obs	Mean	Std. Dev.	Min	Max
NCSKEW	26927	-0.300	0.698	-2.280	1.613
ISO	26927	0.203	0.402	0	1
Media	26927	3.308	1.334	0	7.095
TURNOVER	26927	-0.126	0.475	-1.977	0.985
RET	26927	-0.113	0.096	-0.541	-0.012
SIGMA	26927	4.451	1.756	1.538	10.419
DA	26927	0.009	0.089	-0.262	0.317
ANALYST	26927	1.506	1.180	0	3.784
SIZE	26927	22.173	1.298	19.805	26.179
LEV	26927	0.439	0.205	0.056	0.879
ROA	26927	0.041	0.059	-0.212	0.210
MB	26927	0.626	0.245	0.122	1.150
GROWTH	26927	0.176	0.420	-0.568	2.732

Note: The definition of variables is shown in Table 1.

in voluntary environmental regulation. The standard deviation of voluntary environmental regulation is 0.402. The media's mean value and standard deviation are 3.308 and 1.334, respectively. This statistic is similar to previous studies [10, 37, 57]. In addition, the mean, standard deviation, and minimum and maximum values of our control variables illustrate the characteristics of the sample observations.

Results and Discussion

This paper first studies the direct effect of voluntary environmental regulation on stock price crash risk and then shows the moderating effect of media attention. We provide the Pearson correlation coefficients between explanatory variables in Appendix A, and the results show our research models do not suffer from the multicollinearity problem.

Basic Model

Columns (1) and (2) of Table 3 respectively show the direct effect of voluntary environmental regulation on the risk of the stock price crash and the regulatory impact of media attention, by the ordinary least squares (OLS) estimates. The results show that voluntary environmental regulation has a significantly negative effect on stock price crash risk ($\beta = -0.029$, $p<0.01$), indicating that participating in voluntary environmental regulation can effectively reduce companies' stock price crash risk. This result supports that voluntary environmental regulation encourages companies to prepare environmental statements [46], which prevents the manager from hoarding negative environmental information and helps companies reduce information asymmetry between themselves and investors. Meanwhile, when the environmental influence of the company is highly opaque, the company participates in voluntary environmental regulation, helping signal environmental protection efforts to external stakeholders [11]. Thus, participating in voluntary environmental regulation reduces stock price crash risk by reducing information asymmetry, helping companies build a reputation and insurance effects.

The interaction coefficient of media attention and voluntary environmental regulation is also negative ($\beta = -0.016$, $p<0.05$), indicating that media attention can further enhance the negative relationship between voluntary environmental regulation and stock price crash risk. It is mainly because the media attention plays an important role in the information effect and discipline effect, reducing the tendency of company managers to withhold negative news [37]. Besides, media attention has increased companies' exposure, making investors more aware of the company's efforts on environmental protection. Corporate increases information transparency and corporate social responsibility can help reduce stock

Table 3. Voluntary environmental regulation, media attention, and stock price crash risk.

Variable	(1) NCSKEW	(2) NCSKEW
ISO	-0.029*** (-2.75)	-0.030*** (-2.83)
Media		-0.0005 (-0.11)
ISO*Media		-0.016** (-2.12)
TURNOVER	-0.040*** (-3.90)	-0.040*** (-3.85)
RET	0.612*** (3.20)	0.605*** (3.16)
SIGMA	0.051*** (4.73)	0.051*** (4.69)
DA	0.081 (1.57)	0.080 (1.54)
ANALYST	0.064*** (13.44)	0.065*** (13.50)
SIZE	-0.033*** (-5.62)	-0.030*** (-4.74)
LEV	-0.015 (-0.52)	-0.014 (-0.51)
ROA	-0.161* (-1.68)	-0.161* (-1.68)
MB	-0.164*** (-6.09)	-0.170*** (-6.20)
GROWTH	0.018* (1.65)	0.017 (1.60)
Constant	0.101 (0.80)	0.051 (0.37)
YEAR	Control	Control
IND	Control	Control
Observations	26,927	26,927
Adj_R^2	0.057	0.057
F	42.43	40.59

Note: The table shows the main effects of voluntary environmental regulations (*ISO*) on stock price crash risk (*NCSKEW*) and moderating effect of media coverage (*Media*) based on the OLS. Definitions of the variables are presented in Table 2. ***, **, and * indicate significance at 1%, 5%, and 10%, respectively. Robust standard errors are provided in parentheses.

price crash risk [41, 51]. Therefore, both hypotheses 1 and 2 are supported.

Robustness Test

Propensity Score Matching (PSM)

Participation in voluntary environmental regulations is drive from top managers' concern for environmental

protection, which is non-compulsory implementation and certification [54]. Therefore, some companies may have adopted voluntary environmental regulatory standards but have not been certified through third parties. To avoid endogenous problems caused by sample selection basis, following scholars [58], we use PSM for robustness test. We take the company (*ISO* = 1) involved in voluntary environmental regulation as the experimental group. The results show that voluntary environmental regulation can significantly reduce a company's stock price crash risk (β = -0.025, P<0.05), and the media attention further enhances this negative relationship (β = -0.015, P<0.1). This conclusion is consistent with our previous findings, meaning that our conclusion has good robustness. The results of PSM regression are shown in Table 4.

Instrumental Variable Method

Since this study uses firm-level data, which may cause endogeneity problems due to reverse causality. Hence, following scholars [59, 60], we select industry-year mean value of voluntary environmental regulation (*ISO_Mean*) as instrumental variable, and use the instrumental variable method (2SLS) to solve potential endogeneity problems. The results shown in Table 5 also exhibit that voluntary environmental regulation can significantly reduce the company's stock price crash risk (β = -0.543, P<0.01). This conclusion is consistent with our previous findings, meaning that our conclusion has good robustness.

Replace the Interpreted Variable

In this subsection, we use another measurement to measure stock price crash risk and investigate the relationship between voluntary environmental regulation and stock price crash risk. Referring to the research of scholars [60, 61], we use bottom-up volatility (*DUVOL*) as a measure of stock price crash risk. The calculation method is as follows:

$$DUVOL_{i,t} = \ln \left\{ \frac{(n_u - 1) \sum_{down} W_{i,t}^2}{(n_d - 1) \sum_{up} W_{i,t}^2} \right\} \quad (6)$$

Where $W_{i,t}$ is the firm-specific weekly return, n_u and n_d indicate the number of up and down weeks in year t, respectively.

The regression results of using *DUVOL* as a stock price crash risk measurement are shown in Table 6. The regression coefficient between voluntary environmental regulation and company's stock price crash risk is significantly negative (β = -0.018, P<0.01), and media attention further enhances this negative relationship (β = -0.012, P<0.05). This conclusion is consistent with our previous regression results.

Table 4. Propensity score matching (PSM).

Variable	(1) NCSKEW	(2) NCSKEW
ISO	-0.025** (-2.29)	-0.026** (-2.368)
Media		-0.003 (-0.492)
ISO*Media		-0.015* (-1.913)
TURNOVER	-0.029** (-2.44)	-0.029** (-2.406)
RET	0.482** (2.06)	0.468** (1.992)
SIGMA	0.046*** (3.51)	0.045*** (3.448)
DA	0.151** (2.27)	0.149** (2.233)
ANALYST	0.055*** (9.69)	0.056*** (9.839)
SIZE	-0.032*** (-4.52)	-0.027*** (-3.491)
LEV	-0.025 (-0.73)	-0.024 (-0.704)
ROA	-0.132 (-1.13)	-0.129 (-1.101)
MB	-0.188*** (-5.84)	-0.197*** (-6.037)
GROWTH	0.023 (1.64)	0.022 (1.580)
Constant	0.125 (0.82)	0.033 (0.200)
YEAR	Control	Control
IND	Control	Control
Observations	18,534	18,534
Adj R^2	0.059	0.059
F	31.13	29.82

Note: The table shows the main effects of voluntary environmental regulations (*ISO*) on stock price crash risk (*NCSKEW*) and moderating effect of media coverage (*Media*) based on the PSM estimators. Definitions of the variables are presented in Table 2. ***, **, and * indicate significance at 1%, 5%, and 10%, respectively. Robust standard errors are provided in parentheses.

Further Analysis

Corporate Ownership

As state-owned companies may undertake more political tasks in operation [62], they have both economic and social functions [63]. State-owned companies may differ from private companies regarding information transparency and environmental protection

Table 5. Instrumental variable method (2SLS).

Variable	First stage	Second stage
	(1) ISO	(2) NCSKEW
ISO_Mean	1.022*** (15.33)	
ISO		-0.543*** (-3.93)
TURNOVER	-0.004 (-0.57)	-0.042*** (-3.88)
RET	-0.027 (-0.26)	0.601*** (3.04)
SIGMA	-0.013** (-2.25)	0.045*** (3.93)
DA	-0.075*** (2.83)	0.042 (0.78)
ANALYST	0.010*** (3.65)	0.070*** (13.43)
SIZE	0.004 (1.32)	-0.031*** (-5.04)
LEV	0.017 (1.14)	-0.007 (-0.24)
ROA	0.234*** (4.61)	-0.033 (-0.32)
MB	0.041*** (2.70)	-0.145*** (-5.10)
GROWTH	-0.021 (-4.20)	0.007 (0.66)
Constant	-0.079 (-1.09)	0.119 (0.91)
YEAR	Control	Control
IND	Control	Control
Observations	26,927	26,927
Adj_R²	0.059	0.025
F	31.13	39.63

Note: The table shows the main effects of voluntary environmental regulations (*ISO*) on stock price crash risk (*NCSKEW*) based on the 2SLS estimators. Definitions of the variables are presented in Table 2. ***, **, and * indicate significance at 1%, 5%, and 10%, respectively. Robust standard errors are provided in parentheses.

Table 6. Replace the interpreted variable (DUVOL).

Variable	(1) DUVOL	(2) DUVOL
ISO	-0.018*** (-2.59)	-0.019*** (-2.67)
Media		-0.001 (-0.26)
ISO*Media		-0.012** (-2.39)
TURNOVER	-0.027*** (-3.91)	-0.027*** (-3.86)
RET	0.338*** (2.67)	0.332*** (2.62)
SIGMA	0.028*** (3.87)	0.027*** (3.82)
DA	0.051 (1.45)	0.049 (1.41)
ANALYST	0.039*** (12.32)	0.040*** (12.44)
SIZE	-0.034*** (-8.59)	-0.032*** (-7.40)
LEV	-0.014 (-0.74)	-0.014 (-0.73)
ROA	-0.106* (-1.65)	-0.105 (-1.64)
MB	-0.078*** (-4.26)	-0.083*** (-4.46)
GROWTH	0.006 (0.85)	0.006 (0.80)
Constant	0.278*** (3.28)	0.236*** (2.60)
YEAR	Control	Control
IND	Control	Control
Observations	26,927	26,927
Adj R²	0.062	0.062
F	46.90	44.89

Note: The table shows the main effects of voluntary environmental regulations (*ISO*) on stock price crash risk (*DUVOL*) and moderating effect of media coverage (*Media*) based on the OLS estimators. Definitions of the variables are presented in Table 2. ***, **, and * indicate significance at 1%, 5%, and 10%, respectively. Robust standard errors are provided in parentheses.

efforts. Therefore, in further analysis, we explore the impact of property rights differences on the relationship between voluntary environmental regulation and stock price crash risk, assess the moderating effect of media attention.

Table 7 shows the results of different ownership subsamples. From the direct effect of voluntary environmental regulation on stock price crash risk shown in columns (1) and (3), we find that the coefficient of voluntary environmental regulation in subsample of state-owned companies is significantly

negative (β = -0.036, P<0.05), but the coefficient of that in subsample of non-state companies is not significant (β = -0.022, P>0.1). These results show that the participation of state-owned companies in voluntary environmental regulation is more effective than that of non-state companies in reducing stock price crash risks. Because economic performance is the main goal pursued by local government, state-owned companies are vulnerable to government intervention due to their political background, thus

Table 7. Heterogeneity of property rights.

Variable	(1) NCSKEW	(2) NCSKEW	(3) NCSKEW	(4) NCSKEW
	State-owned firm		Non-state-owned firm	
ISO	-0.036** (-2.14)	-0.030* (-1.73)	-0.022 (-1.62)	-0.027* (-1.96)
Media		0.005 (0.82)		-0.005 (-0.86)
ISO*Media		-0.017 (-1.42)		-0.017* (-1.71)
TURNOVER	0.023 (0.96)	0.022 (0.96)	-0.054*** (-4.54)	-0.053*** (-4.52)
RET	0.904*** (2.73)	0.897*** (2.71)	0.542** (2.19)	0.530** (2.14)
SIGMA	0.052*** (2.95)	0.052*** (2.93)	0.052*** (3.60)	0.052*** (3.57)
DA	0.090 (1.08)	0.088 (1.07)	0.059 (0.89)	0.058 (0.86)
ANALYST	0.071*** (9.04)	0.070*** (8.98)	0.048*** (7.73)	0.049*** (7.90)
SIZE	-0.041*** (-4.60)	-0.042*** (-4.37)	-0.007 (-0.79)	-0.001 (-0.06)
LEV	0.069 (1.56)	0.070 (1.57)	-0.027 (-0.70)	-0.026 (-0.69)
ROA	0.067 (0.41)	0.070 (0.43)	-0.243** (-2.04)	-0.245** (-2.05)
MB	-0.151*** (-3.55)	-0.149*** (-3.47)	-0.233*** (-6.50)	-0.246*** (-6.76)
GROWTH	0.016 (0.93)	0.016 (0.93)	0.014 (1.02)	0.013 (0.94)
Constant	0.292 (1.55)	0.317 (1.57)	-0.391** (-2.18)	-0.503*** (-2.64)
YEAR	Control	Control	Control	Control
IND	Control	Control	Control	Control
Observations	11,099	11,099	15,828	15,828
Adj R^2	0.061	0.061	0.052	0.052
F	20.19	19.27	22.26	21.43

Note: The table shows the main effects of voluntary environmental regulations (*ISO*) on stock price crash risk (*NCSKEW*) and moderating effect of media coverage (*Media*) in subsample of property rights based on the OLS estimators. Definitions of the variables are presented in Table 2. ***, **, and * indicate significance at 1%, 5%, and 10%, respectively. Robust standard errors are provided in parentheses.

state-owned companies invest in production rather than environmental protection; while non-state companies will actively meet environmental requirements to establish relationships with local governments and maintain their social image [64], which leads to lower environmental information transparency of state-owned companies compared with non-state companies. Therefore, when state-owned companies participate in voluntary environmental regulation, it can improve the transparency of environmental information better and reduce the potential environmental risks expected

by investors, helping them decrease stock price crash risks.

Columns (2) and (4) of Table 7 report the moderating effect of media attention. We find that media attention has no significant moderating effect on state-owned companies (β = -0.017, P>0.1). However, it can significantly enhance the negative relationship between voluntary environmental regulation and stock price crash risk of non-state companies (β = -0.017, P<0.1). We believe that this is because state-owned companies disclose more social information in their operation

Table 8. Positive news and negative news.

Variable	(1) Positive News NCSKEW	(2) Negative News NCSKEW
ISO	-0.029*** (-2.735)	-0.031*** (-2.914)
Media	-0.001 (-0.239)	0.000 (0.019)
ISO*Media	-0.014* (-1.829)	-0.015* (-1.793)
TURNOVER	-0.040*** (-3.853)	-0.040*** (-3.878)
RET	0.604*** (3.162)	0.607*** (3.173)
SIGMA	0.051*** (4.688)	0.051*** (4.704)
DA	0.080 (1.541)	0.080 (1.542)
ANALYST	0.065*** (13.478)	0.064*** (13.473)
SIZE	-0.030*** (-4.741)	-0.031*** (-4.846)
LEV	-0.014 (-0.499)	-0.015 (-0.523)
ROA	-0.159* (-1.661)	-0.162* (-1.693)
MB	-0.170*** (-6.206)	-0.168*** (-6.125)
GROWTH	0.017 (1.607)	0.017 (1.608)
Constant	0.050 (0.367)	0.064 (0.473)
YEAR	Control	Control
IND	Control	Control
Observations	26,927	26,927
Adj R^2	0.0571	0.0571
F	40.57	40.52

Note: The table shows the moderating effect of both positive and negative media news (*Media*) on the relationship between voluntary environmental regulations (*ISO*) and stock price crash risk (*NCSKEW*) based on the OLS estimators. Definitions of the variables are presented in Table 2. ***, **, and * indicate significance at 1%, 5%, and 10%, respectively. Robust standard errors are provided in parentheses.

[65], which improves information transparency. At the same time, as state-owned companies undertake more political tasks [62], their exposure in the media is also higher than that of non-state companies. Therefore, media attention can improve the information asymmetry problem in non-state companies, helping reduce stock price crash risks.

Positive and Negative Reporting

Negative news has a more significant impact on investors than positive news, leading to overreaction to negative news and herd behavior [66, 67]. Negative news also makes it impossible for management to continue to hide negative news, increasing stock price crash risk. Therefore, we divided the number of media attention into positive and negative news to explore the moderating effect of positive or negative news on the relationship between voluntary environmental regulation and stock price crash risk.

Column (1) of Table 8 shows the moderating effect of positive news. The regression coefficient is significantly negative, indicating that positive news enhances the negative relationship between voluntary environmental regulation and stock price crash risk (β = -0.014, P<0.1). In addition, the regression results of negative news shown in column (2) of Table 8 also show a significant negative relationship (β = -0.015, P<0.1). This conclusion indicates that both positive and negative news significantly enhance the negative relationship between voluntary environmental regulation and stock price crash risk. We believe this is mainly because the negative news is not a one-time disclosure of the negative news hidden by the managers but plays a role in improving information transparency. Meanwhile, positive news helps the company build a reputation and reduces potential risk for investors.

Conclusions

In this paper, we examine the impact of voluntary environmental regulation on corporate stock price crash risk by assessing the moderating effect of media attention. By using 26,927 annual observations of 3432 companies listed in A-shares from 2008 to 2020 as a research sample, we find that voluntary environmental regulation can effectively reduce the risk of corporate stock price crash, which supports the Porter hypothesis. Media attention enhances the negative relationship between voluntary environmental regulation and stock price crash risk. In further analysis, we consider the nature company's property rights and find that voluntary environmental regulation can better help state-owned companies reduce stock price crash risk. However, the moderating effect on non-state companies is not significant. Media attention has no significant on state-owned companies. In addition, we find that both positive and negative media attention promote the negative relationship between voluntary environmental regulation and stock price crash risk.

Based on our conclusions, we propose the following suggestions. First, for policymakers, they should provide flexible compliance approaches, like voluntary environmental regulation, which could reduce stock price crash risk of firms. However, voluntary environmental regulation requires companies to make

Appendix A

Appendix A Correlation analysis

	NCSKEW	ISO	TURNOVER	RET	SIGMA	DA	ANALYST
NCSKEW	1						
ISO	-0.015***	1					
TURNOVER	-0.035***	-0.011*	1				
RET	-0.012	0.047***	-0.269***	1			
SIGMA	0.026***	-0.049***	0.248***	-0.971***	1		
DA	0.012***	-0.016**	-0.046***	0.007	-0.007	1	
ANALYST	0.090***	0.042***	-0.008	0.125***	-0.122***	0.116***	1
SIZE	-0.075***	0.034***	0.135***	0.254***	-0.303***	0.005	0.386***
LEV	-0.058***	-0.034***	0.114***	0.036***	-0.044***	-0.101***	-0.012**
ROA	0.057***	0.039***	-0.103***	0.084***	-0.081***	0.369***	0.410***
MB	-0.139***	0.011*	-0.060***	0.333***	-0.369***	-0.010	-0.058***
GROWTH	0.036	-0.023	-0.052	-0.066	0.074	0.085***	0.137
	SIZE	LEV	ROA	MB	GROWTH		
SIZE	1						
LEV	0.485***	1					
ROA	-0.001**	-0.356***	1				
MB	0.551***	0.375***	-0.216***	1			
GROWTH	0.040	0.036	0.231	-0.035	1		

a series of changes and adopt new environmental management methods. Therefore, policymakers could encourage firms to participate in voluntary environmental regulation by providing technical assistance and organizing training to make firms avoid additional compliance costs. Secondly, for company managers, they should actively participate in voluntary environmental regulation, which can reduce stock price crash risk by reducing information asymmetry and helping companies build a reputation and insurance effects. Finally, news media should play an active role in supervision and propaganda to help companies improve information transparency and prevent management from hoarding "negative news".

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Conflict of Interest

The authors declare no conflict of interest.

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