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The ESG disclosure and the stock price crash risk

-evidence from China

Hanrui Tai and Huidi Zhang

Abstract

With the continuous improvement of China's ESG information disclosure system, the quality of ESG information disclosure will have an important impact on the stock price crash risk. However, there is no literature in China to study the relationship between ESG information disclosure and stock price crash risk. Taking China listed companies from 2010 to 2022 as a research sample, this paper empirically tests the impact and mechanism of ESG information disclosure on stock price crash risk. The study found that corporate ESG information disclosure can increase the risk of stock price crash. The mechanism test shows that under the "information effect", ESG information disclosure alleviates the stock price crash risk by partially increasing the degree of information asymmetry. This may be due to China's voluntary ESG information disclosure system, which makes ESG information disclosure a method for companies to increase their share prices and then causing the price to suffer a greater negative impact after it deviates from the actual value. The heterogeneity analysis found that the promotion effect of ESG information disclosure on stock price crash risk is weaker in companies audited by the four major international accounting firms and with higher analyst attention. This may be due to investors' higher focus on the company and investors' trust in professional auditors. This study expands the research on the economic consequences of corporate ESG information disclosure, and has important practical significance for strengthening the construction of China's ESG information disclosure system.

Key words: ESG, Stock price crash risk, Information asymmetry

Contents

1. Introduction

In order to regulate and guide the ESG（Environment，Social and Governance）information disclosure behaviour of listed companies in China, the framework for ESG information disclosure was established by China Securities Regulatory Commission on 15 June 2018. The ESG information disclosure system is an important foundation system for China's capital market to implement the strategic objectives of "carbon peaking and carbon neutrality". With the help of government policies and the market, ESG information disclosure by Chinese enterprises is growing rapidly.

Stock price crash risk captures the likelihood of sudden but infrequent extreme negative returns. Crash risk cannot be dispersed through diversification (Kim et al., 2014). Numerous academic studies have shown that stocks are more likely to have extremely negative returns than extremely positive returns. Therefore, the studies about crash risk has significant financial sense to study the stock price crash risk given its obvious implications for investors, shareholders and regulators. Crash risk studies not only contribute to traditional risk management and asset portfolio, but also asset pricing and corporate finance(Chen et al., 2017; Habib et al., 2018; Chang et al., 2017;). Stock price crashes often bring huge losses to investors and cause huge market volatility. Understanding the factors of stock price crash risk can better avoid greater stock market risk. Therefore, we want to study whether China's ESG information disclosure can reduce the stock price crash risk of Chinese stocks and provide a reference for the introduction of the ESG information disclosure regulatory system for Chinese listed companies in the future.

Statistics from the China Capital Research Institute show that that about 45% of China listed companies have issued ESG reports in 2022. The ESG information has a significant impact on corporate stock prices. With the continuous improvement of China's ESG information disclosure system, the quality of ESG information disclosure is gradually improving. As China's ESG information disclosure system and quality continue to improve, ESG information disclosure will have an increasing impact on the risk of share price collapse. This the first

study focuses on the relationship between corporate ESG information disclosure and stock price collapse risk in China's listed companies. The aim is to contributes to the existing literature on the economic consequences of ESG information disclosure and emphasizes the importance of enhancing China's ESG information disclosure system for both regulatory development and practical implementation.

According to our research, the stock price crash risk of listed companies is positively correlated with corporate ESG disclosure. At the same time, the corporate social responsibility disclosure of the previous year has a greater predictive effect on the stock price crash risk of this year. ESG information disclosure through the information asymmetry part intermediation plays a role in stock price crash risk. In the listed companies audited by the Big Four accounting firms, ESG information disclosure is negatively related to the stock price crash risk, and at the same time, it is significantly different from the listed companies that are not audited by the Big Four accounting firms. In the companies that analysts pay more attention to, the impact of ESG information disclosure on the stock price crash is smaller than listed companies that pay less attention and the difference is significant.

2. Literature Review

Stock price crash is one of the specific manifestations of the problems caused by information asymmetry, and information disclosure can alleviate this problem. ESG disclosures provide the market with an indicator beyond a company's financial risk, which is analogous to long-term sustainability. (Crash risk and ESG disclosure). There are currently four theories to explain the mechanism by which information disclosure mitigates crash risk.

First, the most mainstream is the point proposed in Jin and Myers (2006) that skewness and negative price jumps do not entirely originate from an exogenous stochastic process of information generation.

Jin and Myers assumed managers have motivates to hoard bad news and a large price decreases happened when accumulated bad news beyond some triggering and coming out suddenly.

Jin and Myers' (2006) theory agrees with the anecdotal evidence described

above that corporate scandals spark negative spirals of stock prices. The model of Jin and Myers (2006) predicts that information asymmetry between corporate insiders and outside investors heightens crash risk because managers have the ability and incentives to withhold bad news for an extended time frame, permitting hidden bad news to stockpile. More importantly, that theoretical model allows the identification of several firm-specific crash risk determinants, including financial reporting and corporate disclosures, managerial incentives and characteristics, capital market transactions, corporate governance mechanisms, and informal institutional mechanisms.(more about article 2006)

Models developed by Bleck and Liu (2007) and Benmelech et al. (2010) further extend the theory of Jin and Myers (2006). In the Bleck and Liu (2007) model, historical cost financial reporting allows managers to proceed with a poor investment project and thus be compensated before the project expires because the outside world cannot assess the project's market value. The Benmelech et al. (2010) model proposes that managers holding equity-based contracts continue with negative net present value projects to maximize the value of their compensation packages. Both patterns suggest an incentive for management to hoard bad news -- a precursor to a price crash.

The second explanation for crash risk is based on default risk. In a different vein, firms with higher default risks are more likely to release extremely bad news or extremely good news, because they will either fail or continue as a going concern. Previous literature has used firm size and leverage as proxies for default risk, but empirical research thus contradicts this claim that there is a negative correlation between leverage and crash risk (Hutton et al., 2009; Kim et al., 2011a,b) , while in fact leverage should be positively correlated with bankruptcy risk (Camblelle et al., 2008). One possible explanation for this surprising result could be that highly leveraged companies were initially undervalued by investors, reducing the likelihood of a subsequent price crash. Consistent with this interpretation, Cambelel et al. (2008) show that highly leveraged firms generate higher average future returns than low leverage firms (Zhu, 2016, p. 355).

Hong and Stein (2003) develop a theoretical model that incorporated in

investors' belief heterogeneity. This model begins with the observation that short selling is constrained (e.g. mutual funds). The private signals of pessimistic investors are not impounded into prices if they cannot express their views by short-selling, and some bad news were hidden. However, if other previously optimistic investors exit the market, the former group of investors may become the marginal buyers. Thus, previously hidden bad news surfaces and results in a price crash.

Cao et al. (2002) suggest an 'information blockage' model for explaining price crash. informed investors are more determined to engage in active trading in the wake of upward price trends. In contrast, less informed traders are naturally sceptical about the true nature of the signals and hence delay trading until the price drops. Therefore, when the economic outlook turns pessimistic and marginal investors with little news enter the market, a price correction is inevitable. Therefore, information congestion can generate negative return skewness after price increases and positive return skewness after price declines (Zhu, 2016). Another source of crash risk is the volatility feedback effect (eg French et al., 1987; Campbell and Henschel, 1992), where large price movements can cause investors to reassess market volatility, increasing the required risk premium. An increase in the risk premium lowers the equilibrium price, which reinforces the effect of bad news but offsets the effect of good news, creating a negative skewness" (Hutton et al., 2009, p. 68).

These theories have been validated in many empirical studies, which has tested hypotheses akin to the managerial bad news hoarding and the theory developed by Jin and Myers (2006). Jin and Myers (2006) investigate the likelihood of stock price crashes in firms in different countries and found that countries with greater opacity has bigger probability of a stock crash. Hutton et al. (2009) demonstrate that opaque financial reporting at the company level sparked a price crash. Policy and regulatory measures can reduce information asymmetry to a certain extent and improve transparency. For example, DeFond et al. report in their 2015 article that the implementation of International Financial Reporting Standards (IFRS) reduced the crash risk of non-financial firms. The selection of

specific accounting standards will also affect the management of the company, which in turn affects the crash risk.

Kim and Zhang (2016) document crash risk decreases for firms with conservative accounting policies. Kim et al. (2011b) conclude that corporate tax avoidance has a positive association with crash risk, because aggressive tax strategies allowed managers to conceal negative information. Papers from Robin and Zhang (2015) and Callen and Fang (2017) show that auditor industry specialization and auditor tenure, respectively, reduce crash risk. Management incentives and corporate governance mechanisms also contribute to the risk of collapse. Managers hoard bad news likely because of concerns about careers and short-term compensation.

Kim et al. (2011a) and Kim, Wang, and Zhang (2016), found that management's compensation incentives and overconfidence may lead to crash risk respectively. Andreou et al. (2016) found a negative correlation between crash risk and proxies for corporate governance, which was measured by indicators such as the proportion of independent directors on audit committees, and audit industry expertise. Kim et al. (2014) and Chen et al. (2017) respectively pointed out that companies with high ratings of CSR and high-quality internal controls exhibited lower crash risks.

Consistent with the theory of Hong and Stein (2003), empirical research shows that crash risk is more pronounced in stocks that experience large amounts of abnormal trading volume and have high past returns. For example, Callen and Fang (2013) point out that the stability of institutional investors reduces crash risk. Boubaker et al. (2014) revealed a positive link between excessive control and stock price crashes. Chang, Chen, and Zolotoy (2017) present evidence that stock liquidity constitutes a managerial incentive to withhold bad news.

Murata and Hamamori (2021), with companies listed on the STOXX 600, S&P 500 and Nikkei 225, document a negative correlation between ESG disclosures and crash risk. Feng et al.(2021) also found a negative correlation between these variables in a sample of firms in China.

There are many studies investigating the relationship between the ESG and

crash risk from different perspectives. Regarding crash risk, some study the crash risk of a specific company, and some study the crash risk of the overall market, and different metrics can also be selected. Regarding ESG information disclosure, there are overall ESG and separate studies on E, S, and G. In the previous article(Crash risk and ESG disclosure), the author concluded that the mitigation effect of ESG information disclosure on crash risk will vary according to the degree of market development. As an emerging market, China is striving to develop and improve its financial market, and the concept of ESG is gradually being valued. Issues related to internal corporate governance have also begun to come into focus. Therefore, we are interested in the relationship between corporate ESG disclosure and crash risk.

Our study has the following research significance：

1. The Chinese stock market has unique characteristics, such as the range of stock increases and decreases (The market trading prices of listed companies in China can rise or fall by no more than 10% a day and 20% in some sectors.) and t+1 transaction time(Shares purchased on the day cannot be sold). Using the Chinese stock market as the sample for the study is beneficial to enrich the study.

2. As an emerging market, the Chinese stock market is still in the initial stage of ESG assessment and currently, no study have focused on the impact of ESG disclosure on stock price crashes in China.

3. Mechanistic Analysis and Research Hypothesis

The more ESG information disclosed by a company and the higher its quality, the more beneficial it is in reducing the degree of information asymmetry. This phenomenon is referred to as the "information effect" of ESG information disclosure in this paper. Simultaneously, ESG information disclosure helps establish effective communication channels between companies and investors, thereby influencing investor attention and sentiment, and their investment behaviour. Based on the "information effect," previous study(Quan et al., 2015) have indicated that the fundamental cause of stock price collapse lies in the manipulative behavior of internal personnel towards company-specific information. In terms of information manipulation strategies, they include both

concealing negative information and exaggerating positive information.

On the one hand, in situations of information asymmetry, the management has the incentive and ability to hide negative information for their own interests. When negative information accumulates to a certain extent, it triggers a stock price collapse. Additionally, the management may also exaggerate the disclosure of ESG-related information for the purpose of obtaining resources and managing market value. When the management exaggerates positive news, it sends a "positive" signal to external investors, leading to an overvaluation of the stock price that does not align with the actual situation. Once the true conditions are exposed, the stock price experiences a sharp decline. During the disclosure of environmental information, companies may engage in "excessive packaging" and overload disclosure, which deviates from factual environmental information disclosure patterns, thereby increasing the risk of stock price collapse. Particularly in the current stage, due to the voluntary, selective, and low standardization nature of ESG information disclosure by Chinese listed companies, the management is more likely to engage in information management and selectively report positive news, making it difficult for investors to distinguish the company's true value and exacerbating the risk of stock price collapse.

On the other hand, the disclosure of ESG information by companies provides external investors with more information about the company's characteristics, including its active fulfillment of environmental, social, and governance responsibilities. This information helps investors understand the company's operations and sustainable development, reducing the degree of information asymmetry between internal personnel and external investors. Lower information asymmetry significantly reduces the risk of stock price collapse. A strong ESG performance delivers positive signals to the external market. The disclosure of information about environmental, social, and governance responsibilities by companies will facilitate investors in making correct investment decisions, avoiding the "herding effect" and "crowd behavior," and ensuring that the stock price reflects the company's operational information more accurately and effectively, thereby avoiding stock price bubbles and reducing the likelihood of

stock price collapse.

Therefore, based on the above analysis, we proposes the following competitive hypotheses:

H0: Under the influence of the "information effect," the disclosure of ESG information by companies can reduce the risk of stock price collapse.

H1: Under the influence of the "information effect," the disclosure of ESG information by companies can exacerbate the risk of stock price collapse.

4.   Literature and Empirical Research Methodology

The research methods used in this paper include：

(1) Literature research method. We read the relevant literature in English and Chinese, and want to sort out the studies that the impact of ESG information disclosure on the risk of listed companies, the measurement of ESG information disclosure and the stock price crash risk of listed companies. Then develop new ideas and methods based on the studies of other scholars, present new ideas and organize clear theoretical and logical framework.

(2) Empirical analysis method. The data obtained are analyzed empirically by using statistical tool software such as Stata and Python, and the main research variables are analyzed by establishing econometric models to draw a final conclusion.

5.   Research Design and Description of Variables

5.1 Sample selection and data source

The ESG information dsclosure scores are collected from Sino-Securities Index Information Service (Shanghai) Company and the Chinese stock market data are collected from CSMAR(a widely used dataset for Chinese financial research). The time frame is from 2010 to 2022. And selected the listed companies as follows: (1) Excluding financial companies.(2) Excluding companies that have been listed for less than one year or unlisted. (3) Removal of data with incomplete key indicators. (4) To eliminate the effect of extreme values, all continuous variables below 1% and above 99% of the quartiles were trimmed. All data can be obtained from public database and there are no potential ethical issues.

5.2 Variables describation

Explained variable

We uses two indicators to measure stock price crash risk. One indicator is NCSKEW, which represents the negative skewness of stock returns after market adjustment(Hutton, 2019). The other indicator is DUVOL, which measures the volatility change of stock price changes(Xu, 2014).

The calculation process is as follows: first, establish model (1) and calculate the market-adjusted weekly returns using the residuals ε_{it} obtained from model (1).

$$r_{it} = \alpha + \beta_{1t}r_{mt-2} + \beta_{2t}r_{mt-1} + \beta_{3t}r_{mt} + \beta_{4t}r_{mt+1} + \beta_{5t}r_{mt+2} + \varepsilon_{it} \quad (1)$$

In the model, r_{it} represents the weekly return of individual stock i in week t, and r_{mt} represents the market-weighted average return of all stocks in week t. To reduce the impact of asynchrony in stock trading, lagged two-period indicators (r_{mt+2} and r_{mt+1}) and previous two-period indicators (r_{mt-2} and r_{mt-1}) of r_{mt} are added. The residuals ε_{it} are obtained based on model (1). The market-adjusted returns of stock i in week t are measured by W_{it}, where $W_{it} = \ln(1 + \varepsilon_{it})$.

Then, the following two indicators are constructed: The first indicator is NCSKEW, which measures the negative skewness of individual stock's weekly returns after market adjustment. This indicator is calculated according to model (2), and a larger NCSKEW indicates a greater stock price crash risk.

$$NCSKEW_{it} = -\frac{\left[n(n-1)^{\frac{3}{2}}\sum W_{it}^3\right]}{\left[(n-1)(n-2)(\sum W_{it}^2)^{\frac{3}{2}}\right]} \quad (2)$$

The second indicator is DUVOL, which measures the volatility difference of stock price changes. Specifically, it compares the market-adjusted weekly returns W_{it} of stock i with the average annual returns, and divides the data samples into two phases: Up and Down. The standard deviations of stock returns for these two phases (Ru, Rd) are calculated. DUVOL is then calculated according to model (3), and a larger DUVOL indicates a higher stock price crash risk.

$$DUVOL_{it} = \ln\left\{\frac{[(n_u-1)\sum R_d^2]}{[(n_d-1)\sum R_u^2]}\right\} \quad (3)$$

Explanatory variables

(1) ESG Disclosure (ESG): The core explanatory variable use the Bloomberg ESG disclosure score, which measures the extent of ESG information disclosure by companies. A higher score indicates better ESG disclosure.

(2) Information Asymmetry (IA): The non-tradability ratio is used to measure the level of information asymmetry in listed companies, in order to examine the impact of information effect on stock price crash risk. A higher IA value indicates a higher level of information asymmetry. The calculation formula is

$$IA = \sqrt{\frac{|Average\ annual\ stock\ return|}{\ln(Stock\ annual\ trading\ volume)}} \tag{4}$$

Control Variables

According to the previous study, the control variables are selected as follows. Except ESG lagging indicators, all control variables are all current period.

(1)Lagged weekly return skewness ($L1\_SKEW$) and volatility difference of stock returns ($L1\_DUVOL$) from the previous week;

(2)MB represents the market-to-book ratio of the company;

(3)$Agency$ is the agency cost, expressed by the annual adjusted management expense rate of the industry;

(4)DA represents earnings management, measured by the absolute value of discretionary accruals calculated using the modified Jones model;

(6)$Inshold$ represents the proportion of institutional investors' holdings;

(7)$StockYield$ represents the stock yield;

(8)$Analyst$ represents analyst coverage, calculated as ln(1+number of analysts);

(10)Big represents the type of audit opinion, 1 for the Big Four(PWC, DT,KPMG,EY) auditors and 0 otherwise;

(11)$Size$ represents the company size, measured by the natural logarithm of total assets;

(12)Lev represents financial leverage, measured by the total asset-liability ratio;

(13)Roa represents the return on assets;

(14)Industry effect ($Industry$) and year effect ($Year$) are also controlled.

5.3 Model Specification

The basic regression model to examine the impact of ESG disclosure on stock price crash risk is specified as follows:

$$RISK_{it} = \alpha + \alpha_1 ESG_{it} + \alpha_2 Contorls_{it} + \alpha_3 Industry_{it} + \alpha_4 Year_{it} + \varepsilon_{it} \quad (5)$$

6. Empirical tests and analysis of results

6.1 Variable descriptive statistics

Using STATA16.0 statistical analysis software to conduct descriptive statistical analysis on the sample data, and the descriptive statistical results of the main variables are shown in Table 1. According to the calculation process, we can see that *NCSKEW* is the skewness of the calculation rate of return. Stocks with high *NCSKEW* values have a high standardized negative skew trend and are more prone to large negative returns. And *DUVOL* is to separate all the weeks in which the return of a specific period is lower than the annual average from the weeks in which the return of a specific week is higher than the annual average, and calculate the standard deviation of these sub-samples separately. *DUVOL* was then estimated as the logarithm of the ratio of the standard deviation of declining weeks to the standard deviation of rising weeks. Stocks with a high *DUVOL* ratio are more prone to large negative price volatility because negative returns are more volatile than positive returns,

The maximum value of NCSKEW is 5.0127, the minimum value is -5.2497, the maximum value of DUVOL is 2.3623, and the minimum value is -2.7770. The average values of NCSKEW and DUVOL are -0.3314 and -0.2239 respectively, indicating that the two explained variables for measuring the risk of crash probability distribution is similar to the existing research results.

Table 1 : Variable descriptive statistics

Variable	N	Mean	SD	MIN	MAX
NCSKEW	32097	-0.3314	0.7522	-5.2497	5.0127
DUVOL	32097	-0.2239	0.4818	-2.7770	2.3623
ESG	32097	4.0961	1.0831	1	8
Agency	32097	0.0900	0.1631	0.0008	1.608
MB	32097	4.3250	41.8304	-3213	1493
IA	32097	0.1181	0.0645	0.0008	0.8189
DA	32097	0.0706	0.1026	0	6.2556
Inshold	32097	45.73	25.00	0	97.81
StockYeild	32097	0.16235	0.5951	-0.8215	14.2777
Analyst	32097	1.3848	1.2021	0	4.3307
Big	32097	0.0622	0.2416	0	1
Size	32097	22.3359	1.3331	15.58	28.64
Lev	32097	3.2195	3.5399	0.5111	141.24
Roa	32097	0.0358	0.0769	-1.8591	1.2848

The mean value of ESG is 4.0691, and the standard deviation is 1.0831, indicating that there are large differences in the performance of ESG information disclosure among different companies. The minimum and maximum values of IA are 0.0008 and 0.8189, indicating that the degree of information asymmetry among enterprises varies greatly, and some enterprises have relatively high degrees of information asymmetry.

The distributions of other control variables are within a reasonable range and are similar to the existing research results. The correlation analysis between variables shows that the correlation coefficient between NCSKEW and DUVOL is relatively large, 0.8715, and the significance is 1%. The two indicators can effectively measure the stock price crash risk. At the same time, the absolute values of the correlation coefficients of other variables are generally less than 0.5, that is, there is no serious multicollinearity among the variables.

6.2 The basic Regression

Table 2 The Basic Regression

variables	(1) NCSKEW	(2) NCSKEW	(3) DUVOL	(4) DUVOL
ESG	0.0035 (0.0017)**		0.0063 (0.0028)**	
L.ESG		0.0154 （0.0049)***		0.0108 (0.0301)***
Lev	-2.4131 (0.1963)***	-2.4209 (0.2093)***	-1.7853 (0.1237)***	-1.7647 (0.1325)***
Size	-0.0148 (0.0047)***	-0.0133 (0.0052)**	-0.0198 (0.0030)***	-0.0189 (0.0033)***
Inshold	0.0006 (0.0002)***	0.0005 (0.0002)**	0.0004 (0.0001)***	0.0003 (0.0002)**
StockYeild	2.3267 (0.1978)***	2.3517 (0.2103)***	1.7241 (0.1247)***	1.7149 (0.1332)***
MB	-0.00014 (0.00005)***	-0.00014 (0.00006)***	-0.00005 (0.00003)*	-0.00005 (0.00003)
DA	0.1089 (0.0412)***	0.1291 (0.0696)**	0.0288 (0.0278)	0.0423 (0.03673)
Agency	0.0139 (0.0269)	0.0269 (0.0344)	0.0175 (0.0136)	0.0268 (0.0167)
Roa	0.0348 (0.0708)	0.0539 (0.0708)	0.0446 (0.0439)	0.0748 (0.0484)
Con	-0.1213 (0.1032)	-0.1870 (0.1152)	-0.0981 (0.06634)	-0.3354 (0.0734)***
Year and Industry	Yes	Yes	Yes	Yes
N	29273	24517	29273	24517
R^2_a	0.038	0.039	0.048	0.046

***, **, * mean significant at the level of 1%, 5% and 10% respectively

Table 2 shows the basic regression of ESG information disclosure and stock

price crash risk. The regression coefficient of ESG in column (1) is 0.0035 and is significantly positively correlated with the negative skewness of weekly return (NCSKEW) at the level of 5%. The regression coefficient of ESG in column (3) is 0.0063 and is significantly positively correlated with the weekly return volatility (DUVOL) at the level of 5%. The higher the price, the more likely it will exacerbate the risk of stock price crashes that may occur in the future. In order to control the endogeneity problem, the L.ESG is put into the model for regression analysis. As shown in columns (2) and (4), the regression coefficients obtained by the two indicators of NCSKEW and DUVOL are still significant and both are positive, that is, the significant positive correlation between the level of ESG information disclosure of companies and the risk of stock price crash is still established. At the same time, it can also be found that the ESG coefficient in the t-1 period is larger than the ESG variable coefficient in the current period. This is not the case with stock markets in many other countries and we first find this relationship between ESG and crash risk in China.

We think that due to the China currently voluntary disclosure system of ESG information, the production of ESG reports or the disclosure of ESG information requires costs, listed companies are more likely to issue more ESG information reports in order to boost stock prices and create a better corporate social image to attract investors and raise the stock price to a higher level, making the stock price deviate from the intrinsic value of the enterprise. Later when the stock price returns to normal value the following year will see greater decline.

6.3 Information effect test

From the regression analysis, it can be known that the ESG information disclosure behavior of enterprises can affect the stock price crash risk. According to the analysis of this paper, the different effects of ESG information disclosure lead to information asymmetry, which affects the risk of stock price crash. The following transmission mechanism is proposed: ESG information disclosure—information asymmetry—stock price crash risk. Path a, Path b and Path c are constructed to test the mediating effect of information asymmetry.

Path a:

$$RISK_{it} = \alpha + \alpha_1 ESG_{it-1} + \alpha_2 Contorls_{it} + \alpha_3 Industry_{it}$$
$$+\alpha_4 Year_{it} + \varepsilon_{it} \tag{6}$$

Path b:

$$IA_{it} = \alpha + \alpha_1 ESG_{it-1} + \alpha_2 Contorls_{it} + \alpha_3 Industry_{it}$$
$$+\alpha_4 Year_{it} + \varepsilon_{it} \tag{7}$$

Path c:

$$RISK_{it} = \alpha + \alpha_1 ESG_{it-1} + \alpha_2 IA_{it} + \alpha_3 Contorls_{it} + \alpha_4 Industry_{it}$$
$$+\alpha_5 Year_{it} + \varepsilon_{it} \tag{8}$$

Table 3 Information effect test

variables	Path a NCSKEW	Path b IA	Path c NCSKEW	Path a DUVOL	Path b IA	Path c DUVOL
L.ESG	0.0154	0.0008	0.01485	0.0108	0.0008	0.0103
	$(0.0049)^{***}$	$(0.0004)^{***}$	$(0.0049)^{***}$	$(0.0301)^{***}$	$(0.0004)^{***}$	$(0.0031)^{***}$
IA			0.6024			0.5862
			$(0.0867)^{***}$			$(0.0593)^{***}$
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year and Industry	Yes	Yes	Yes	Yes	Yes	Yes
Con	-0.1870	0.1904	0.3016	-0.3354	0.1904	0.4470
	(0.1152)	$(0.0090)^{***}$	$(0.1160)^{***}$	$(0.0734)^{***}$	$(0.0090)^{***}$	$(0.741)^{***}$
N	24517	24517	24517	24517	24517	24517
R^2_a	0.039	0.055	0.041	0.046	0.055	0.049

The results are shown in Table 3. The ESG explanatory variables were all regressed with a one-period lag. Among them, in the regression analysis of the measurement indicator NCSKEW, the ESG coefficient of the model Path a was 0.0154, which was significant at the 1% level. The coefficient for the information effect in Path b is 0.0008, which is significant at the 1% level, indicating that ESG information disclosure can increase the degree of information asymmetry of enterprises. The coefficient for the information asymmetry degree IA in Path c is 0.6024, which is significant at the 1% level and the coefficient for ESG is 0.0145, which is significant at the 1% level. The coefficient for ESG in path c is significantly lower than that in path a, indicating that the degree of information

asymmetry has a mediating effect when using the NCSKEW index to measure the stock price crash risk. We are also the first to find that more disclosure of ESG information in the Chinese stock market has increased the information asymmetry of stocks, and these information asymmetries are also one of the important reasons for stock price crashes.。

Similarly, in the regression analysis of DUVOL, the coefficients in path a b and c are all significant at the 1% level, and path c is significantly lower than path a. When the DUVOL index is used to measure the stock price crash risk, the degree of information asymmetry also plays an intermediary role. From this, it can be concluded that the information effect has a partial intermediary effect in the inhibition of ESG information disclosure on stock price crash risk, indicating that ESG information disclosure can increase the risk of stock price crash by increasing the degree of information asymmetry, which verifies hypothesis H1.

7. Heterogeneity analysis

7.1 External audits

High-quality external audits can suppress the risk of stock price crashes by improving the quality of accounting information and reducing the degree of information asymmetry. In the heterogeneity analysis of whether the auditors are audited by the four major international accounting firms, the explanation with a lag of one period is used. The regression results are shown in Table 4. Columns (1) and (3) show that when the stock price crash risk is measured by NCSKEW, the regression coefficient of ESG information disclosure on stock price crash risk in big 4 audits is negative and and in other audits are positive. Both are significant at the 1% level and use dummy variables to regress to show that the difference between them is significant at 5% level.

From the significance level, ESG information in the four major audit groups can suppress the risk of stock price crash, and ESG in the non-four audit groups can promote the stock price crash risk.

Table 4 External audits test

variables	Big4=1(1)	Big4=1(2)	Big4=0(3)	Big4=0(4)
	NCSKEW	DUVOL	NCSKEW	DUVOL
L.ESG	-0.0078	-0.0017	0.0164	0.0113
	(0.0018)***	(0.0011)*	(0.005)***	(0.0032)***
Controls	Yes	Yes	Yes	Yes
Year and Industry	Yes	Yes	Yes	Yes
Con	-0.0607	0.3031	0.1515	0.2912
	(0.3738)	(0.2597)***	(0.1286)	(0.0811)***
N	1660	1660	22875	22875
R^2_a	0.145	0.157	0.037	0.042

Columns (2) and (4) show that when the measure of stock price crash risk is DUVOL, the regression coefficient of ESG information disclosure on stock price crash risk in the four major audit groups is negative the other is positive and both are significant at the 10% level. And use dummy variables to regress to show that the difference between them is significant at 10% level. It shows that when the volatility difference index (DUVOL) is used to measure the stock price crash risk, the inhibitory effect of ESG information disclosure on the stock price crash risk is shown in the companies audited by the Big Four accounting firms.

7.2 Analysts

As an important information intermediary in the capital market, analysts have an important impact on alleviating information asymmetry, which may affect the inhibitory effect of ESG information disclosure on stock price crashes.

Table 5 Analysts test

variables	High analysts concern	High analysts concern	Low analysts concern	Low analysts concern
	NCSKEW	DUVOL	NCSKEW	DUVOL

	(1)	(2)	(3)	(4)
L.ESG	0.01385 (0.0070)***	0.0113 (0.0049)**	0.02964 (0.009)***	0.0663 (0.0039)*
Controls	Yes	Yes	Yes	Yes
Year and Industry	Yes	Yes	Yes	Yes
Con	0.2709 (0.1827)	0.3320 (0.1261)***	0.9585 (0.2576)***	0.7214 (0.1042)***
N	9423	9423	15094	15094
R^2_a	0.074	0.157	0.041	0.049

In the analysis of heterogeneity regarding analyst attention, explanatory variables lagged one period were used to regression.The samples larger than the median number of analysts are defined as a group with high analyst attention, and those below the median are defined as a group with low analyst attention.

The regression results are shown in Table 5. Columns (1) and (3) show that when the stock price crash risk is measured by NCSKEW, ESG information disclosure has a significant impact on stock price crash risk in the group with high and low analyst attention. Use dummy variables to regress to show that the difference between them is significant at 1% level. The regression coefficients of are all positive and significant at the 1%. Columns (2) and (4) are the regression results when the index of stock price crash risk is DUVOL. Use dummy variables to regress to show that the difference between them is significant at 1% level. Among them, in the group with high attention, the coefficient is positive and all are significant in the both groups.

As show in the table 4 and 5, the values of regression coefficients in high analyst attention group is smaller than in the low attention group. Therefore, to a certain extent, it can be concluded that when analysts pay more attention, ESG information disclosure has a more obvious inhibitory effect on stock price crash risk. At present, the release of ESG information in China is voluntary, and companies can choose to report good news or not bad news. We believe that when analysts pay more attention to companies, the information is transmitted faster,

and the company is watched by "many pairs of eyes" in the market, the analysts will be more detailed Analyzing the ESG information released by the company, false or fake ESG news will be more difficult for the market to accept. At this time, it is more difficult for ESG information to cause negative fluctuations in stock prices. We also believe that companies that hire more professional auditing institutions to conduct audits are more confident in their own business conditions. At the same time, investors have confidence in more professional auditing institutions and the company's ESG report is more likely to be recognized by investors. Thereby reducing the negative fluctuation of the company's stock price.

8. Research Conclusions and Policy Recommendations

This study examines the impact and mechanism of corporate ESG information disclosure on stock price crash risk using Chinese listed companies from 2010 to 2022 as the research sample. The results indicate that corporate ESG information disclosure may increase the risk of stock price crash. Further examination of the influencing mechanism reveals that corporate ESG information disclosure may exacerbate stock price crash risk by increasing information asymmetry, known as the "information effect." Heterogeneity analysis also finds that ESG information disclosure has a weaker promoting effect on stock price crash risk for companies audited by the Big Four accounting firms and companies that attract higher analyst attention.

Based on the above research findings, this paper proposes the following policy recommendations. Firstly, government regulatory agencies should establish a sound ESG information disclosure system. They can draw on mainstream ESG information disclosure standards both domestically and internationally, and develop disclosure guidelines tailored to the characteristics of Chinese listed companies. In terms of disclosure methods, a semi-mandatory disclosure system could be considered, which requires companies to disclose ESG information and provide explanations if they choose not to disclose. In terms of disclosure content, specific key information that needs to be disclosed should be clearly defined, and industry-specific ESG information disclosure indicators could be developed. Secondly, incentive and constraint mechanisms for ESG information disclosure

should be established. Strengthening cooperation between government regulation and professional supervision, encouraging third-party institutions and audit firms to audit ESG information disclosure, and rewarding companies with high-quality ESG information disclosure (e.g., government subsidies, green credit preferences, tax reductions) while imposing penalties such as public criticism and fines on companies with poor evaluations of ESG information disclosure. Through incentive and constraint mechanisms, companies can be encouraged to improve the quality of information disclosure and reduce the risk of stock price crash. Thirdly, the role of intermediaries such as securities analysts and auditors should be emphasized, and their negative impact should be avoided. It is important to prevent intermediaries from distorting information for personal gain and guide them to play a positive guiding role, which helps improve the company's information environment and reduce the risk of stock price crash. Finally, efforts should be made to guide and educate investors, enhancing their professional competence and information acquisition abilities. This will enable investors to form investment concepts based on company value, avoid herd behavior and speculative psychology, and reduce the risk of stock price crash.

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