DSSR

Discussion Paper No. 134

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December, 2022

Data Science and Service Research
Discussion Paper

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December 2022

Abstract

We show a theoretical relationship between ESG disclosure and stock price crash risk and provide statistical evidence to support their non-monotonic relation using firm-level data from China. The weak relationship between these two indicators reported in previous studies is attributable to the linearity assumption used in the analysis.

JEL classification: M14, G32, H70
Keywords: Corporate environmental responsibility; Firm value; Centralization; Local protectionism; Ownership type

*This paper has been prepared for publication in the book "Topical Issues in Development Economics" edited by Desire Avom and Gilles Dufrenot (Cambridge Scholars Publishing) and was presented in the Fourth Conference on CSR, the Economy and Financial Markets (2021) and the Third Fall Conference of the Nippon Finance Association (2021). We would like to acknowledge financial support from the Tohoku Forum for Creativity via the thematic program "Environmental and Financial Risks" and thank Akira Hibiki, Giang Nguyen, Pakesh Pandey,Yuto Yoshinaga, and conference participants for their constructive comments on the earlier version of the paper, "The Environmental, Social, and Governance (ESG) and Stock Price Crash Risk: Evidence from China".

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1 Introduction

Environmental problems like environmental pollution, ecological imbalances, and resource depletion can severely hinder economic development and social progress. With the growing public concern about intensifying environmental conservation to attain sustainable economic and social growth, sustainable development has gained more and more attention nowadays (Caiado et al., 2017). For example, some measures have been taken to alleviate environmental problems, such as the adoption of the 2015 Paris Climate Agreement, a legally binding international treaty on climate change, that aims to limit the increase in global average temperature to 2 °C. To achieve a win-win economic development and environmental protection situation, corporate sustainability is also an essential part that should be seriously concerned (Lloret, 2016).

ESG[1] is increasingly becoming a consensus in recent years (Qiu and Yin, 2019). ESG is an extended notion of the green economy and responsible investment. It is currently an essential indicator for measuring enterprises' sustainable development level (Qiu and Yin, 2019). People from all walks of life, especially investors and financial practitioners, are growingly depending on ESG information and metrics to evaluate long-term company value[2][3] (Escrig-Olmedo et al., 2013). In the meantime, in response to increasing stakeholder interest in ESG, many related agencies, e.g., Morgan Stanley Capital International (MSCI), Thomson Reuters, and Bloomberg, started to report ESG and associated data.

Stock price crash risk[4] namely, extremely negative return outlier, is linked with the negative skewness of individual stock return distribution (Kim et al., 2014). It is the conditional skewness of return distribution.[5] This is crucial for investors to make investment judgments and conduct risk control (Chen et al., 2001). Crash risk is based on the idea that corporate managers often tend to hide negative news within the company from the outside market, which accumulates negative news over time. When managers prevent bad information from flowing into the market, the distribution of firms' stock returns will be an asymmetric shape (Hutton et al., 2009). If the collection of bad news exceeds a certain level, it will be instantly exposed to the market, causing

[1]ESG has three dimensions, namely: environmental (e.g., wastewater discharge and environmental penalties), social (e.g., charitable donations and employee benefits), and governance (e.g., board composition and political relations) dimensions.

[2]The Institute for Governance and Accountability (2017) reported that 82% of S&P 500 firms published sustainability reports in 2017, compared to 53% of S&P 500 firms in 2012.

[3]The SynTao Green Finance documented that about 1,021 (27%) A-share listed companies issued ESG reports in 2020 in China, among them, 259 (86%) of the CSI 300 listed companies released reports in 2020, indicating that the top listed companies already have a strong awareness of ESG disclosure.

[4]Stock price crash risk and crash risk are interchangeable.

[5]Conditional skewness, defined as the third moment of the return distribution, is an essential feature of the return distribution, along with the mean (first moment) and variance (second moment).

a sharp decrease in stock price.

The relationship between ESG disclosure and crash risk is now examined in many developed countries. However, the empirical findings are mixed about whether ESG disclosure affects crash risk positively or negatively (Murata and Hamori, 2021). Besides, this relationship in China is worth special attention for the following reasons. First, China started ESG disclosure much later than developed countries and thus lacks efficient data evidence.[6] Second, the unique institutional background in China may lead to a distorted relationship, which is common in other economic research. Thus, although there is expected to be a significant link between ESG disclosure and crash risk based on prior research, we should be cautious about investigating the specific relationship. There are two dominant factors overall. First, a higher ESG score means a higher level of corporate information disclosure, less harmful news hoarding by managers and increased transparency of the firm's financial reporting (Deng and Cheng, 2019). However, higher ESG is more likely to be used as a tool by managers to pursue their interests, thereby reducing credibility level and increasing crash risk (Huang, 2021).

Kim et al. (2014) have examined the relationship between corporate social responsibility (CSR) and stock price crash risk. However, it is more beneficial to examine the ESG information and crash risk because of the difference between ESG and CSR reports.[7] The difference between the two terms mainly contains three aspects. First, the target audience is different. The target audience of the CSR report is very scattered, while the ESG report is very focused.[8] Therefore, the ESG content usually has a relatively more "substantial" relationship with the company's stock market performance. Second, the frame and content are different. CSR reports are generally not mandatory, while ESG reports typically have relatively detailed guidelines and requirements.[9] This is reflected in the content, which requires coverage of certain content and even quantitative disclosure. Third, the release and use are different. The CSR report emphasizes dissemination and communication functions, and the release is flexible. At

[6]For example, the world's first ESG Domini 400 Social Index, later renamed as MSCI KLD 400 Social Index, was released in the United States in 1990. However, Chinese firms issued the first ESG report in 2006.

[7]Previous studies like Kim et al. (2014) mainly concerned the relation between the social dimension and firm-specific future stock crash risk. ESG is preferred to CSR, as it explicitly delineates its concerns (environmental, social, and governance).

[8]The CSR report audience is nearly all stakeholders, including government regulatory agencies, employees, partners, communities, and NGOs, and therefore the CSR's content must meet the requirements of different sub-groups. The ESG report audience is mainly capital market participants, especially institutional investors.

[9]Companies have more freedom in preparing CSR reports, as long as they follow the general reporting framework, like the GRI standard, to expand the content, and it emphasizes the readability. However, in addition to referring to the GRI standards and other frameworks, it is also necessary for ESG reports to follow other specific requirements.

the same time, the ESG report is mainly for investors and has strict release requirements.[10] Some listed companies are beginning to realize the value of communicating with investors on ESG issues and use ESG reports as an important tool for investor communication.

This paper explores the connection between ESG disclosure and firm-specific stock price crash risk. Our methodology involves both analytical and reduced-form models. We first develop an analytical model based on two dominant factors and estimate the non-monotonic relationship. We then empirically evaluate this relationship. The dataset covers panel observations of Chinese A-share listed companies from 2006 to 2020. The key variable, the ESG score, is collected from Bloomberg Professional Service, and others are collected from China Stock Market & Accounting Research database and Wind database. The findings hold after robustness checks, like addressing endogenous concerns.

This paper contributes to the existing literature in the following three aspects. First, unlike existing research (e.g., Murata and Hamori, 2021), which provides only empirical evidence, we develop an analytical model to reveal the hidden mechanism. Second, our analytical model includes dominant factors in two competing theories, demonstrating that both theories work under different conditions. Our schema, therefore, can give a reasonable explanation of previously mixed findings. Third, our evidence from the updated Chinese dataset is rare and complementary to existing empirical research, primarily in developed countries. The analytical model reveals a non-monotonic (negative about the left-end boundary point but positive with regard to the right-end) relationship between ESG disclosure and crash risk. Our empirical results also verify this non-monotonic relationship using a Chinese dataset and support that the ESG disclosure level acts as a "market stabilizer" when the ESG score is low and acts as a "market destroyer" after the ESG score reaches a specific level. Therefore, the study offers significant implications for the corporate manager, investor, policymaker, and regulator. Specifically, transparency and credibility of the financial report are two positive factors that make ESG more valuable.

The rest of this paper is arranged as follows. We discuss the prior research in the next section. Section 3 presents the literature evidence of non-monotonic. Section 4 is the analytical model, revealing the non-monotonic relation. Section 5 provides a reduced-form analysis, verifying a non-monotonic relationship. Section 6 presents our empirical results, and Section 7 concludes the paper.

[10]CSR report pays special attention to the readability and dissemination of the report. There are various release forms, like the PDF version, H5 version, video version, etc. Some companies may organize special conferences or combine them with corporate brand activities. However, The ESG report must be released within the specified time, uploaded to the company's official website, and submitted to the exchange.

2 Literature review

2.1 Environmental, social and governance

The ESG literature has mainly focused on the link between ESG and financial performance (Xie et al., 2019). Some academics examine whether the ESG score could be considered a probable essential element for successful investment (Richardson, 2009), and whether investors are more willing to invest in companies with a more satisfactory CSR profile, which might lead to more promising financial performances (De Bakker et al., 2005). Regarding the relationship between ESG and firm performance, two opposite views prevail. On the one hand, based on the Porter hypotheses (Porter and Linde, 1995), corporate social responsibility engagement, primarily environmental responsibility engagement, can stimulate firm innovative behavior that generates additional gains to offset costs. Thus a suitable CSR approach may improve corporate financial performance (CFP). Numerous empirical investigations find CSR is positively related to CFP (Deng et al., 2013). On the other hand, CSR activities bring additional costs caused by inefficient resource allocation, which will make the firm less competitive in the free and competitive market (Sternberg, 1997). Much research uncovered that CSR is negatively correlated with a firm's financial performance (Margolis and Walsh, 2003). Different from the positive or negative associations, some researchers saw a neutral association between CSR and CFP (McWilliams and Siegel, 2001; Moore, 2001). Besides the relationship of ESG to FP, some studies suggest other factors that can strengthen or weaken this relationship, such as innovation, long-term orientation (Wang and Bansal, 2012), stakeholder relations, managerial action, financial Slack, and so on (Kim and Statman, 2012; Duque-Grisales and Aguilera-Caracuel, 2019).

The connection between ESG and the firm-level stock return has also been explored. Belkaoui (1976) is one of the first scholars to study the linkage between corporate exposure to environmental information and stock performance. His research uncovered that companies that reported environmental information underperformed others before publishing it and surpassed them afterward. Klassen and McLaughlin (1996) propose an analytical model that supports the notion that environmental performance awards are associated with significantly positive returns, whereas environmental crises are heavily correlated with significant negative returns. Graham and Maher (2006) support a negative association between environmental risk management and corporate bond ratings or yields. More recently, Kim et al. (2014) investigate how CSR impacts stock price crash risk and shows a negative influence of CSR on crash risk. Demers et al. (2020) investigate whether ESG scores could function as indicators of share price resilience during the COVID-19 humanitarian crisis and documented that ESG scores

offer no such positive explanatory power for returns during COVID-19.

2.2 Stock price crash risk

There is a myriad of literature on stock price crash risk, and we can divide them into five groups. The first group studies determinants of financial reporting and corporate disclosures. Hutton et al. (2009) use the cumulative accrual to measure a firm's earnings management, and the findings demonstrate that companies with more opaque economic information are prone to experience share price crashes. Chen et al. (2017) find that companies with smoother earnings are more prone to share price crashes. DeFond et al. (2015) investigate the effect of adopting different accounting standards on corporate crash risks and discover that adopting International Financial Reporting Standards (IFRS) would reduce a company's crash risk. Zhang et al. (2016) explore the impact of corporate philanthropy (an important part of CSR) on the collapse risk of Chinese companies and verify that it decreases the collapse risk.

The second group of determinants is about managerial incentives and characteristics. Kim et al. (2011) study the impact of CFO equity incentives in compensation plans on businesses' crash risk. Their results show that the higher the CFO option portfolio value ratio, the greater the company's crash risk. Park (2017) finds that differences in the compensation of corporate employees could increase corporate real revenue management (REM) behaviors, accordingly adding the risk of corporate stock price plummeting.

The third group of determinants is related to the capital market. Chen et al. (2001) believe that the trading volume of stocks mirrors the divergence of market investors. Therefore, higher stock trade volume exhibits that some investors perceive negative information inside the company. Callen and Fang (2015) demonstrate that short interest in a company's stock is associated with its risk of a future crash. Ni and Zhu (2016) state that the crash risks of stock prices in the market would increase when short-selling restrictions were removed.

The fourth group is about corporate governance. Andreou et al. (2016) show that companies with a high percentage of independent directors and strict governance policies have a lower probability of collapse. Xu et al. (2014) point out that the perk system of state-owned enterprises will encourage managers to conceal negative news for their own benefit, leading to increased crash risks. Boubaker et al. (2014) find that excessive control positively correlates with stock crashes.

The fifth group is regarding informal institutional mechanisms. Luo et al. (2016) show that companies with political ties to government officers are less at risk of collapse. Li and Chan (2016) discover that holding members of the Chinese Communist Party

(CPC) on the board reduces the collapse risk of the company. Li et al. (2017) explore how social confidence and firms' crash risk link, and the results show that companies located in areas with high social confidence levels generally have lower crash risk.

3 Literature evidence of the non-monotonic relationship

3.1 Benefits of ESG disclosure

There are two opposite views of the effect of ESG on firm-specific crash risk based on earlier literature. Some researchers support a negative relationship since high ESG disclosure helps to mitigate managers' negative news hoarding activities and enhance transparency in firms' financial reports. For example, Gelb and Strawser (2001) uncover that companies that engage in more socially responsible activities tend to supply better financial information disclosures. Because companies with high corporate social responsibility usually have high ethical standards and better information transparency. Eccles et al. (2014) discover that more long-term oriented, highly sustainable companies had better ESG measures and exposure patterns. Non-financial reports could be employed to forecast the anticipated forthcoming economic performance of the company. Investing with consideration of ESG information can help investors bypass 90% of bankruptcies (Lynch and Morgan, 2017). Wu and Hu (2019) reveal a lower crash risk for such firms with high CSR scores. Other researchers, such as Cheng et al. (2014), argue that companies with high ESG transparency have better operational reputations and are more likely to acquire funds at lower costs.

Besides, the stakeholder perspective suggests that stakeholders and firms mutually influence each other (Feng et al., 2021). Higher ESG disclosure helps firms enhance their reputation, which benefits the improvement and maintenance of the firm value. For instance, the Legitimacy Theory view claims that a company's ESG disclosure aims to gain social legitimacy for the environmental or social influences of the company's operations (Lokuwaduge and Heenetigala, 2017). Amid the pressure of the public and stakeholders, ESG disclosure is a good management tool for maintaining a favorable corporate reputation for the enterprise (Brammer and Pavelin, 2008). CSR, as an intangible asset, can strengthen the reputation of companies, improve performance and safeguard the interests of shareholders in the long run (Dai et al., 2019).

3.2 Costs of ESG disclosure

By contrast, there is a concern about agency problems that managers may use ESG opportunistically for personal gain. For example, Friedman (2007) argues that CSR may be a kind of agency problem, as companies may employ CSR to conceal corporate misconduct. Consistent with this notion, Petrovits (2006) and Prior et al. (2008) find that CSR boosts a firm's earnings management behaviors. If a firm uses ESG score as a mask to conceal poor information and shift shareholder inspection (Kim et al., 2014). To avoid reputation loss, managers are likely to use the ESG disclosure as a self-interest tool to get promoted, which significantly undermines information transparency (Barnea and Rubin, 2010). Companies with poor performance or earnings management and corruption are more likely to carry out charitable, public welfare, environmental protection, and other social responsibility activities to avoid punishment and show a good image to external stakeholders (Barnea and Rubin, 2010).

3.3 Reconciling the contradictory theoretical concepts

Two main competing perspectives about the relationship exist in the previous literature. One is the stakeholder perspective, which suggests that higher ESG disclosure means lower crash risk. Since a high ESG score reflects that the firm values long-term performance and has a more transparent information disclosure system, it establishes reputational capital and thus reduces crash risk. The other is the agency perspective, which claims that higher ESG disclosure leads to higher crash risk. Because of the interest conflict between shareholders and managers, the managers might construct an illusion of a high ESG level to obtain personal gain, which retains bad news in firms and increases the crash risk.

Thus, the nature of the ESG-crash risk relationship may be more complex than a simple positive or negative one. There may be conflicts between the two, and the relationship assessment also depends on the level of the ESG disclosure. The law of diminishing marginal returns supports the theory of the "too-much-of-a-good-thing" effect, which can serve as an explanation of why beneficial expectations (ESG disclosure) might lead to negative outcomes (crash risk) when they are beyond a certain level, where the costs exceed benefits. The "too-much-of-a-good-thing" effect assumes that the relationship between two objects has a specific maximum, after which an extra rise introduces a decrease in the consequence, resulting in a non-monotonic link, like the Environmental Kuznets Curve (Trumpp and Guenther, 2017; Aghion et al., 2019; Andreoni and Levinson, 2001). Therefore, an inflection point of the ESG level appears when the stock price crash risk reaches its minimum (the optimal level), and after that, there is a positive link (Pierce and Aguinis, 2013). In a word, it is necessary to find a

balance between the two extremes.

Therefore, we hypothesize that there is a non-monotonic relationship between the ESG disclosure level and the stock price crash risk. When the ESG disclosure level is low, the increased ESG disclosure indicates a higher level of transparency and higher stakeholder benefits, which leads to less bad news hoarding. As the ESG disclosure level rises to a certain level in China, ESG report is used more as a self-interest tool for management, it may bring additional costs caused by agency problems and inefficient resource allocation, which would put the firms in an unfavorable position and increase the stock price crash risk.

4 Analytical model of the non-monotonic relationship

According to the above literature review, there are two competing perspectives on the ESG-crash risk relationship. The stakeholder perspective suggests that high ESG companies are committed to long-term firm value and stakeholder trust building. Therefore, high ESG companies will provide more transparent information (in this case, high ESG means high transparency and low crash risk). The other is the agency perspective, which means that when a company's shareholders and managers have conflicting interests, they will harm shareholders and maximize their own interests. Therefore, high ESG may be a tool for managers to seek their personal interests (high ESG means low credibility and high crash risk). Since the relationship between ESG and crash risk is affected by both channels, we show below that their relationship is characterized as non-monotonic. A non-monotonic function is one that does not always increase or decrease. More specifically, a function is non-monotonic if its first derivative (which does not have to be continuous) changes sign. That is, a non-monotonic function between y and x can be defined as $y(x)$ where two different x_1 and x_2 in the domain of x follows $\frac{dy}{dx_1} * \frac{dy}{dx_2} < 0$.

4.1 Model setup

A company's cash flow (C_t) production process is as follows:

$$C_t = K_0 X_t \tag{1}$$

where K_0 is a constant, representing the initial investment, and X_t is the shocks that affect the cash flow-generating process. X_t is the sum of three independent parts:

$$X_t = f_t + \theta_{1,t} + \theta_{2,t} \tag{2}$$

Here f_t captures a macroeconomic factor that affects all firms in the market and is known by all people. $\theta_{1,t}$ and $\theta_{2,t}$ capture firm-specific factors. $\theta_{1,t}$ is public information, such as annual financial reports, news, etc. $\theta_{2,t}$ is information within the firm, such as negative news hidden by managers. The managers inside the company observe both $\theta_{1,t}$ and $\theta_{2,t}$, but outsiders only know $\theta_{1,t}$. $\theta_{1,t}$ and $\theta_{2,t}$ are independent of each other. For simplicity and rationality, we assume that f_t, $\theta_{1,t}$ and $\theta_{2,t}$ are stationary AR(1) with the same AR(1) parameter φ ($0 < \varphi < 1$). We assume that the error terms, ε_{t+1}, $\xi_{1,t+1}$, and $\xi_{2,t+1}$ are all normally distributed with mean 0 and variance 1. That is:

$$\begin{aligned} f_{t+1} &= f_0 + \varphi f_t + \varepsilon_{t+1}, \\ \theta_{1,t+1} &= \theta_{1,0} + \varphi\theta_{1,t} + \xi_{1,t+1}, \\ \theta_{2,t+1} &= \theta_{2,0} + \varphi\theta_{2,t} + \xi_{2,t+1}, \end{aligned} \tag{3}$$

Thus, X_t is also stationary AR(1):

$$X_{t+1} = X_0 + \varphi X_t + \lambda_{t+1} \tag{4}$$

where $X_0 = f_0 + \theta_{1,0} + \theta_{2,0}$, and $\lambda_t = \varepsilon_t + \xi_{1,t} + \xi_{2,t}$.

Next, we define κ as the ratio of firm-specific to market variance:

$$\kappa = \frac{\mathrm{Var}\left(\theta_{1,t} + \theta_{2,t}\right)}{\mathrm{Var}\left(f_t\right)} \tag{5}$$

And we define a firm's transparency as the ratio of the variance of $\theta_{1,t}$ to the sum of the variances of $\theta_{1,t}$ and $\theta_{2,t}$:

$$\eta = \frac{\mathrm{Var}\left(\theta_{1,t}\right)}{\mathrm{Var}\left(\theta_{1,t} + \theta_{2,t}\right)} = \frac{\mathrm{Var}\left(\theta_{1,t}\right)}{\mathrm{Var}\left(\theta_{1,t}\right) + \mathrm{Var}\left(\theta_{2,t}\right)}, \tag{6}$$

The second equation holds because $\theta_{1,t}$ and $\theta_{2,t}$ are independent of each other.

4.2 Transparency and crash risk are negatively related

Given the company's current (t) stock price, the return for the next period ($t+1$) depends on two factors. One is market factor $\tilde{\varepsilon}_{t+1}$, captured by the market return $r_{m,t+1}$; and a firm-specific factor $\tilde{\xi}_{t+1}$. Thus, R^2 of a firm, represented by the portion of variance explained by the market, is:

$$R^2 = \frac{\mathrm{Var}\left(\varepsilon_{t+1}\right)}{\mathrm{Var}\left(\varepsilon_{t+1}\right) + \mathrm{Var}\left(\xi_{t+1}\right)} = \frac{1}{\kappa\eta + 1} \tag{7}$$

Here κ is the ratio of firm-specific to market variance, defined in Formula (2.5). η is the firm's transparency, defined in Formula (2.6). From the equation, we found that, when other things are equal, the less transparent the company is, the greater the R^2. In other words, transparency is inversely proportional to R^2.

Next, we want to show that crash risk is proportional to R^2. Jin and Myers (2006) state that stocks have higher R^2 in less developed countries. Higher R^2 means a higher portion of variance explained by the market. In developing countries (with immature financial markets), such as China, where external regulation is weak, company managers are more likely to steal company profits for their own benefit. We assume managers can take away money, and the takeaways depend on market expectations. In this case, if the macroeconomic environment improves year by year and the company's actual profit is 50, 100, and 200 for three consecutive years, the manager would steal 10, 50, and 125 in these three years, respectively. Ultimately, the amount of profit that the company presents to the market is the actual profit minus stealing by managers, namely, 40, 50, and 75. However, in developed countries (with sound financial markets), it is more difficult for companies to manipulate profits due to sound laws, regulations, and supervision systems. Since crash risk means negative news hoarding or potentially exposed takeaway, a high R^2 implies a high level of bad news hoarding or high crash risk. In other words, R^2 is proportional to crash risk, $R^2 \propto$ crash risk. Combining the above formula (7), we obtain the following formula:

$$\text{Crash risk } \propto \frac{1}{\kappa\eta + 1} \tag{8}$$

Crash risk is inversely proportional to transparency.

4.3 Transparency and ESG score are positively related

Companies with high ESG scores disclose more ESG-relevant information to the market, which reflects high transparency. Therefore, we believe that ESG score and transparency are positively related. We assume that this positive relationship satisfies the following, $\eta(ESG = 0) > 0$, $\eta' > 0$ and $\eta'' < 0$. This assumption is reasonable. $\eta(ESG = 0) > 0$ is established because even if no ESG information is disclosed, the company still has positive transparency due to other disclosures, such as financial reports. $\eta' > 0$ is established because ESG disclosure is a form of information disclosure. The higher the ESG score, the more information is revealed, thus higher transparency. $\eta'' < 0$ is established because, intuitively, when the level of ESG disclosure is low, the increased ESG disclosure at this time is important information, resulting in a rapid increase in transparency. When the level of ESG disclosure is high, the increased ESG

disclosure at this time is trivial information and has little impact on the improvement of transparency.

4.4 Credibility and crash risk are negatively related

Managers have two options when negative $\theta_{2,t}$ exists, namely bad news hoarding inside the firm. One is to stay with the company and continue to hide bad news. Then managers will need to pay a certain cost to cover up the bad news. The other is giving up hiding bad news (like leaving the company and getting some money). For the first option, managers need to pay a certain amount in the current year and future to cover up the bad news. We discount future money to the current period. According to Myers (2000), the following formula expresses managers' total cost of sticking with the company to cover up bad news.

$$\begin{aligned} & K_0\theta_{2,t} + PV\left\{K_0\mathrm{E}\left(\theta_{2,t+1} \mid \theta_{2,t}\right), K_0\mathrm{E}\left(\theta_{2,t+2} \mid \theta_{2,t}\right), \ldots; r\right\} \\ & = K_0\left[\theta_{2,t} + \frac{1}{r}\frac{\theta_{2,0}}{1-\varphi} + \frac{\varphi}{1+r-\varphi}\left(-\frac{\theta_{2,0}}{1-\varphi} + \theta_{2,t}\right)\right] \end{aligned} \tag{9}$$

Here, PV stands for discounting future amounts to the current period. r is the risk-free rate. $\varphi\ (0 < \varphi < 1)$ is the AR(1) parameter of $\theta_{2,0}$. $\mathrm{E}\left(\theta_{2,t+1} \mid \theta_{2,t}\right)$ is the conditional expectation of $\theta_{2,t+1}$ given $\theta_{2,t}$. $K_0\theta_{2,t}$ means the cost in period t for managers to cover up bad news $(\theta_{2,t})$. $PV\left\{K_0\mathrm{E}\left(\theta_{2,t+1} \mid \theta_{2,t}\right), K_0\mathrm{E}\left(\theta_{2,t+2} \mid \theta_{2,t}\right), \ldots; r\right\}$ means discounted future costs to period t (given $\theta_{2,t}$).

Under the second option, managers give up hiding bad information, abandon the company, and get a one-time income. This income is related to the market's valuation of the company. According to Myers (2000), the overall valuation of the company by external investors can be expressed as follows:

Manager's stick cost=

$$\begin{aligned} \mathrm{E}\left(K_t \mid f_t, \theta_{1,t}\right) &= \frac{1}{r}\frac{K_0X_0}{1-\varphi} - \frac{\varphi}{1+r-\varphi}\frac{K_0X_0}{1-\varphi} + \frac{\varphi}{1+r-\varphi}K_0\left(f_t + \theta_{1,t} + \frac{\theta_{2,0}}{1-\varphi}\right) \\ &= \frac{1}{r}\frac{K_0X_0}{1-\varphi} + \frac{\varphi}{1+r-\varphi}\left[K_0\left(f_t + \theta_{1,t} + \frac{\theta_{2,0}}{1-\varphi}\right) - \frac{K_0X_0}{1-\varphi}\right] \end{aligned} \tag{10}$$

We assume that credibility will affect the lowering of the market's valuation of the company and that managers get paid $p(0 < p < 1)$ times the company's overall valuation. Therefore, the amount that the manager can get at this time can be expressed as:

Manager's gain=

$$p * (\text{ credibility }) \left\{ \frac{1}{r} \frac{K_0 X_0}{1-\varphi} + \frac{\varphi}{1+r-\varphi} \left[-\frac{K_0 X_0}{1-\varphi} + K_0 \left(f_t + \theta_{1,t} + \theta_{2,t} \right) \right] \right\} \tag{11}$$

The indifference condition (both options[11] are equivalent for managers) of managers is:

$$\begin{aligned} &\mathrm{K}_0 \left[\theta_{2,t} + \frac{1}{r} \frac{\theta_{2,0}}{1-\varphi} + \frac{\varphi}{1+r-\varphi} \left(-\frac{\theta_{2,0}}{1-\varphi} + \theta_{2,t} \right) \right] \\ &+ p * \text{ credibility } \left\{ \frac{1}{r} \frac{K_0 X_0}{1-\varphi} + \frac{\varphi}{1+r-\varphi} \left[-\frac{K_0 X_0}{1-\varphi} + K_0 \left(f_t + \theta_{1,t} + \theta_{2,t} \right) \right] \right\} = 0 \end{aligned} \tag{12}$$

We can see that the higher credibility, the more managers can obtain from the firm, and the less likely they will ditch the company (release bad news). Therefore, we prove that credibility is negatively related to crash risk.

4.5 Credibility and ESG score are negatively related

According to agency theory, when there is interest conflict between shareholders and managers, the managers might construct an illusion of a high ESG level to obtain personal gain, which retains bad news in firms and increases the crash risk. Therefore, there is a negative relationship between ESG scores and credibility. We assume that this negative relationship satisfies the following, $z_2(ESG = 0) = maximum > 0$, $z_2' < 0$ and $z_2'' < 0$. This assumption is reasonable. $z_2(ESG = 0) = maximum > 0$ is established because when no ESG information is disclosed, the possibility of ESG being used by managers as a tool for personal gain is 0, so the credibility is the highest. $z_2' < 0$ is established because as ESG disclosure increases, ESG is more likely to be used by managers as a tool for personal gain and thus lower credibility. $z_2'' < 0$ is established because, intuitively, when the level of ESG disclosure is low, the increased ESG disclosure at this time is more likely to be true information, and the decrease in credibility is not obvious. When the level of ESG disclosure is high, managers are likely to whitewash ESG performance to achieve personal goals or hide bad news, and credibility declines faster as ESG increases.

[11]Specifically, option one is that managers choose to pay a certain amount in the current year and in the future to cover up the bad news; option two is that managers give up hidden information, abandon the company, and get a one-time income.

4.6 Formula simplification for crash risk function on transparency and credibility

According to proposition 4 in Jin and Myers (2006)[12], the return process of a firm's stock satisfies the following formula:

$$\tilde{r}_{i,t+1} = r + \frac{(1+r)\left(\tilde{\varepsilon}_{t+1} + \tilde{\xi}_{t+1}\right)}{X_0(1+r)/r + \varphi\left(f_t + \theta_{1,t}\right)} \tag{13}$$

Where $\tilde{r}_{i,t+1}$ is excess rate of return. r is the risk-free rate, From the above formula, we can see that $\tilde{r}$ is inversely proportional to $\frac{1}{\theta_1}$, namely:

$$r \propto \frac{1}{\theta_1} \tag{14}$$

We assume r_- is the excess rate of return at times of stock crash. When the negative news (θ_2) is exposed to investors, the stock price will fall sharply (crash). Similar to the above formula, we can infer that r_- satisfies the following formula:

$$r_- \propto \frac{1}{\theta_1 + \theta_2} \tag{15}$$

We calculate the crash risk as the proportion of the standard deviation of stock returns on "down" days to that on all days. And since $\mathrm{Var}(X) = \mathrm{E}\left[X^2\right] - \mathrm{E}[X]^2$, we obtain the following formula for crash risk.

$$\text{Crash risk} = \frac{\sum r_-^2}{\sum r^2} = \frac{\sum \mathrm{var}\left(r_-\right)}{\sum \mathrm{var}(r)} \tag{16}$$

Then we substitute formulas (2.14) and (2.15), and obtain:

$$\text{Crash risk} = \frac{\sum_{T-} \mathrm{var}\left(\frac{1}{\theta_1+\theta_2}\right)}{\sum_T \mathrm{var}\left(\frac{1}{\theta_1}\right)} \tag{17}$$

Since $\sum_{r-}$ equals total days multiplied by the probability of negative returns, $\sum_r$ equals total days. Meanwhile, according to the equation formula of the function $\mathrm{var}(f(x)) = \left(f'(E(x))\right)^2 \mathrm{Var}(x)$, we transform the above formula into the following:

$$\text{Crash risk} \propto \frac{T \cdot P_{r_-} \cdot \mathrm{var}\left(\theta_1 + \theta_2\right)}{T \cdot \mathrm{var}\left(\theta_1\right)} = P_{r_-} \cdot \frac{1}{\eta} \tag{18}$$

P_{r_-} represents the probability of occurrence of r_-. It can be seen from the above

[12]It is shown on page 268.

equation that when only considering transparency, the risk is inversely proportional to transparency. This is consistent with intuition.

We then simplify $P_{r\_}$. The indifference condition for managers are:

$$\begin{aligned}&\mathrm{K}_0\left[\theta_{2,t}+\frac{1}{r}\frac{\theta_{2,0}}{1-\varphi}+\frac{\varphi}{1+r-\varphi}\left(-\frac{\theta_{2,0}}{1-\varphi}+\theta_{2,t}\right)\right]\\&+p*(\text{ credibility })\left\{\frac{1}{r}\frac{K_0X_0}{1-\varphi}+\frac{\varphi}{1+r-\varphi}\left[-\frac{K_0X_0}{1-\varphi}+K_0\left(f_t+\theta_{1,t}+\theta_{2,t}\right)\right]\right\}=0\end{aligned} \tag{19}$$

Because other factors are constants, we can simplify the two parts before and after the plus sign into $-\beta_1\theta_2$ and $z_2\cdot\beta_2\cdot(\theta_1+\theta_2)$. Here, we describe the constant term before θ_2 as β_1. We add the "negative sign" to indicate that this is the manager's pay (cost). we describe the constant term before $(\theta_1+\theta_2)$ as β_2. We use z_2 to represent credibility for brevity.

Therefore, we get the following:

$$P_{r\_}=\text{Possibility of releasing bad news }=P\left\{-\beta_1\theta+z_2\beta_2\cdot(\theta_1+\theta_2)<0\right\} \tag{20}$$

$$\begin{aligned}&-\beta_1\theta+z_2\cdot\beta_2\cdot(\theta_1+\theta_2)\\&=(\theta_1+\theta_2)\left[-\frac{\beta_1\theta_2}{\theta_1+\theta_2}+z_2\beta_2\right]\\&=(\theta_1+\theta_2)\left[-\beta_1\left(1-\frac{\theta_1}{\theta_1+\theta_2}\right)+z_2\beta_2\right]\\&=(\theta_1+\theta_2)\left[-\beta_1(1-\eta)+z_2\beta_2\right]\\&\propto\beta_1\eta+\beta_2z_2\end{aligned} \tag{21}$$

Thus,

$$\text{Crash risk}=\frac{1}{\eta}P\left\{\eta+z_2<0\right\} \tag{22}$$

For η (transparency), when η is larger, $\frac{1}{\eta}$ is smaller, p is smaller, and finally, the crash risk becomes smaller. For z_2 (credibility), when z_2 is larger, the crash risk becomes smaller. Therefore, for both transparency and credibility, the risk is inversely proportional to them. This is also consistent with intuition.

4.7 The non-monotonic relation

Based on reasonable assumptions about the relationship of ESG to the two channels (transparency η and credibility z_2) in subsections (2.4.3) and (2.4.5),[13] and the simplified formula for crash risk function on transparency and credibility shown in equation

[13]Specifically, for η, $\eta'>0$ and $\eta''<0$; for z_2, $z_2'<0$ and $z_2''<0$.

(22), we first illustrate the existence of a non-monotonic relationship by specifying the trends of the two boundary points.

The trend of the left boundary point (when ESG is close to the minimum value, that is, the company does not disclose ESG information) is as follows: When ESG increases, η increases substantially, and z_2 decreases by a small amount (or almost unchanged). It can be seen from equation (2.22) that a large increase in η causes a large decrease in crash risk; a small reduction in z_2 results in a tiny increase in crash risk. Therefore, at the left boundary point, when ESG rises, the combined effect of η and z_2 causes a decrease in crash risk. This means that the relationship between ESG and crash risk is negative at the left boundary point, namely, $\frac{d_{Risk}}{d_{ESG_{low}}} < 0$.

The trend of the right boundary point (when ESG is close to the maximum value, that is, the company almost fully discloses ESG information) is as follows: When ESG increases, η increases by a small amount (or almost unchanged) and z_2 decreases substantially. It can be seen from equation (22) that the slight increase in η causes a slight decrease in crash risk; a large reduction in z_2 results in a large increase in crash risk. Therefore, at the right boundary point, when ESG rises, the combined effect of η and z_2 causes an increase in crash risk. This means that the relationship between ESG and crash risk is positive at the right boundary point, namely, $\frac{d_{Risk}}{d_{ESG_{high}}} > 0$.

So far, we have verified $\frac{d_{Risk}}{d_{ESG_{low}}} < 0$ exists when ESG is small (close to the minimum value), $\frac{d_{Risk}}{d_{ESG_{high}}} > 0$ exists when ESG is large (close to the maximum value). Therefore, $\frac{d_{\text{Risk}}}{d_{ESG_{low}}} * \frac{d_{\text{Risk}}}{d_{ESG_{high}}} < 0$, which shows that there is a non-monotonic relationship between ESG and crash risk.

Furthermore, we could select three ESG values to verify the possible non-monotonic relationship between ESG and crash risk. When ESG takes values 1, 20, and 40, respectively (that is, $ESG_1 = 1$, $ESG_2 = 20$, and $ESG_3 = 40$; $ESG_1 < ESG_2 < ESG_3$), it is reasonable that η (transparency) takes the values of 5, 14, and 15, respectively. And z_2 (credibility) takes the values of 15, 14, and 5, respectively. Therefore, we get three pairs of (transparency, and credibility), that is, (5,15), (14, 14), and (15, 5). Substituting these three pairs of values into (2.22), we get the values of crash risk as $\frac{1}{5}P(20)$, $\frac{1}{14}P(28)$, $\frac{1}{15}P(20)$. The size relationship between them is $\frac{1}{5}P(20) > \frac{1}{15}P(20) > \frac{1}{14}P(28)$, namely $Risk_1 > Risk_3 > Risk_2$.

5 Research design

5.1 Data and sample

Our initial sample contains all firms listed on the A-shares (RMB ordinary stock) from China Security Market from 2005 to 2020. Please note that the ESG scores and control

variables are gathered from 2005-2019, and crash risk data is calculated from 2006-2020. Then, we impose the following requirements: (1) excluding enterprises in the financial sector, (2) excluding enterprises with fewer than thirty trading weeks in one year, and (3) excluding observations with missing data. Our sample finally includes 6777 observations with 1017 firms and ranges 16 years. We next winsorize all the continuous variables at 1% and 99% percentages to ease the outliers' influences. Data are collected from China Stock Market & Accounting Research Database (CSMAR), Wind database, and Bloomberg Professional Service. The specific data sources for each variable are shown in Table 1.

[Table 1]

5.2 Measurement of crash risk

Following the prior research, such as Kim et al. (2014) and Zhang et al. (2016), we use two indexes to evaluate a firm's crash risk: the first one is the negative coefficient of skewness of a firm's weekly stock returns ($NCSKEW_{i,t}$); the other is the crash likelihood estimation of the Down-to-Up Volatility ($DUVOL_{i,t}$) of a firm's stock returns. To calculate them, we need first calculate the firm's weekly returns ($W_{i,t}$), defined as the natural logarithm of one plus the residual term, which is obtained from below the market model regression:

$$R_{i,t} = \alpha_i + \beta_1 R_{m,t-2} + \beta_2 R_{m,t-1} + \beta_3 R_{m,t} + \beta_4 R_{m,t+1} + \beta_5 R_{m,t+2} + \varepsilon_{i,t} \tag{23}$$

where $R_{i,t}$ is firm i's stock return during week t. $R_{m,t-2}$, $R_{m,t-1}$, $R_{m,t}$, $R_{m,t+1}$, and $R_{m,t+2}$ are market returns of total value-weighted market index during weeks $t-2$, $t-1$, $t-1$, $t+1$, and $t+2$, respectively. $\varepsilon_{i,t}$ is the residual term.

Then, firm-specific weekly returns ($W_{i,t}$)[14] are calculated below:

$$W_{i,t} = \ln(1 + \varepsilon_{i,t}) \tag{24}$$

Next, $NCSKEW_{i,t}$, is computed via the third moment of firm i's weekly stock returns in year t, divided by the cubed standard deviation of a firm's weekly returns, then multiplied by a negative one. The calculation formula is explicitly shown as follows:

$$NCSKEW_{i,t} = -\left[n(n-1)^{3/2}\sum W_{i,t}^3\right] / \left[(n-1)(n-2)\left(\sum W_{i,t}^2\right)^{3/2}\right] \tag{25}$$

Here n represents the total number of trading weeks of firm i in year t. From the

[14]When $\varepsilon_{i,t}$ is less than -1, $W_{i,t}$ is a missing value. Here 36 observations were deleted.

equation, we know that when $NCSKEW_{i,t}$ rises, the left skewness of the distribution of the excess returns will be more significant, which indicates a higher crash possibility.

Then, we evaluate $DUVOL_{i,t}$, which is formed by taking the logarithm of the proportion of the standard deviation of a firm's weekly stock returns in "up" weeks to that in "down" weeks. Up and down weeks are obtained by comparing returns in that week with a firm's average weekly returns for the year t. When the weekly stock return is larger than the average value, this is an "up" week; when the firm's weekly stock return is smaller than the average value, this is a "down" week. The calculation process is shown below:

$$DUVOL_{i,t} = \log\left\{\left[(n_u - 1)\sum_{DOWN} W_{i,t}^2\right] / \left[(n_d - 1)\sum_{UP} W_{i,t}^2\right]\right\} \tag{26}$$

Here n_u (n_d) indicates the week's number that firm i' weekly stock returns are higher (lower) than the average weekly stock returns during the year t. High $DUVOL_{i,t}$ implies high crash risk.

5.3 Environmental, Social and Governance information

We use ESG scores obtained from the Bloomberg Professional Services platform. Its ESG information is primarily gathered from corporate sustainability reports, financial reports, and firms' news and announcements. The ESG disclosure score measures the transparency of ESG information, and the scoring process takes into account disparities in importance and industry distinctions for each data point. Bloomberg's ESG data varies from 0.1 to 100, with the two extremes representing the minimum level of disclosure and disclosure of all relevant information, respectively.

5.4 Empirical model

To investigate the relationship between firm ESG disclosure and stock price crash risk, we construct the following regression model:

$$CrashRisk_{t+1} = \beta_0 + \beta_1 ESG_t + \beta_2 ESG_t^2 + \beta_3 Controls_t + \text{Industry} + \text{Year} + \varepsilon_t \tag{27}$$

Here the dependent variable, $CrashRisk_{t+1}$, is derived from $Ncskew$ or $Duvol$. ESG is the key independent variable. All independent variables are packaged in year t, with a one-year lag from the dependent variable. This permits us to check whether ESG disclosure in year t can forecast the crash risk in year $t+1$.

The control variables ($Controls$) are those factors that may affect future crash risk based on previous literature (Kim et al., 2014). We first include the lagged variable

of crash risk ($NCSKEW_{i,t}$ or $DUVOL_{i,t}$) for possible serial correlation. Then, we include eight other control variables in the model. Chen et al. (2001) document that, besides trading volume, prior returns can also affect future crash risk because any surging accumulated during past returns is usually followed by a plummet in price. Therefore, we consider past returns (RET), firm size ($SIZE$), and the market-to-book ratio (MB) as control variables. Since investor opinion heterogeneity has a link to the stock price crash risk (Hong and Stein, 2003), the detrended stock trading volume ($DTURN$), an indicator of investors' strategy set diverseness, is also added. Stock volatility ($Sigma$) is included since volatile stocks are expected to undergo a future price crash in a larger chance. Other firm-level variables, including the absolute value of abnormal accruals ($ABACC$) used for measuring earnings management (Hutton et al., 2009), financial leverage (LEV), and profitability (ROA), are also included as control variables. Table 1 shows the variable definitions.

Our empirical analysis regressed the firm-specific crash risk in year t+1 on ESG and other control variables in year t. We considered industry and year-fixed effects ($Industry$ and $Year$ dummies) in our regression. Consistent with the prior literature, we estimate the regression with the standard error modified by a two-dimensional cluster at both firm and year level (Petersen, 2009; Kim et al., 2014). In addition to the panel data regressions, we also consider the endogenous issues which may confuse the accurate relation between ESG and firm-specific crash risk. To lighten the endogenous concerns, we conduct the two-stage instrument variable method (2SLS) with the average ESG of remaining firms in the identical industry as the instrumental variable.

6 Empirical results

6.1 Descriptive statistics

Table 2 and Figure 1 show the yearly sample distribution. We can see that the sample size increased rapidly from the year 2008. It may be due to the increased number of companies that choose to publish ESG reports or the expanded coverage of the Bloomberg database. The two gauges of crash risk (NCSKEW and DUVOL) show relative stability across years, except for the highest crash risk in 2008.[15] The years 2009 and 2016 have the lowest crash risk.[16] The average ESG score keeps increasing over time, while the value is relatively small in the first three years. This means the level of ESG information disclosure by Chinese companies is increasing yearly.

[15]The high value of crash risk in 2008 reflects the financial crisis.

[16]The two years are right after the Chinese stock market crash, thus showing lower stock price crash risk.

We can intuitively see the variations of ESG, NCSKEW, and DUVOL values over the year in Figure 2. The blue line represents ESG values and shows an upward trend by year. This means the firms in our sample are increasing ESG disclosure and investment, and their ESG performance is improving yearly. The NCSKEW and DUVOL values fluctuate over time. The low points in the years 2009 and 2016 were encountered right after the stock market crash in the last year, which released a lot of hidden bad news. The values of two stock price crash risk measurements, NCSKEW and DUVOL in red and green, are very close each year.

[Table 2]

[Figure 1 & 2]

Table 3 reports the descriptive statistics for the major variables used in our regression models. The average values of two crash risk evaluations $NCSKEW$ and $DUVOL$ are -0.342 and -0.235, respectively. The mean ESG score is 21.881. The mean of the detrended average monthly share turnover is 0.042. The mean and standard deviation of firm-specific weekly returns are 0.003 and 0.010, respectively. The firm in our sample has an average book-to-market ratio of 2.133, an average leverage of 0.491, an average return on assets of 0.046, and an average size of 23.095. The mean absolute value of abnormal accruals is 0.053. These data are consistent with the previous literature (Kim et al., 2014).

[Table 3]

Table 4 presents the correlation matrix for the variables used in our main regression models. Pearson's correlation determines the strength and direction of the linear relationship between two variables. In Table 4, the correlation coefficient between F_NCSKEW and F_DUVOL is 0.876 and statistically significant at the 1% level. It means that the two measures for crash risk are highly significantly correlated with each other and capture similar information, although their constructions are quite different. The Pearson correlation coefficient of ESG and F_NCSKEW (F_DUVOL) is -0.003 (-0.008).[17] It shows that there is no linear relationship between ESG and crash risk in bivariate analysis. Spearman's rank-order correlation determines the strength and direction of the monotonic relationship between two variables. The Spearman's rank-order correlation coefficient between ESG and F_NCSKEW (F_DUVOL) is -0.005 (-0.010), indicating a non-monotonic relationship between the two variables.

[Table 4]

Figure 3 intuitively shows the relation between ESG disclosure and firm-specific crash risk. We use "F_NCSKEW" to represent a crash risk in the graph above and "F_DUVOL" to represent a crash risk in the graph below. The red line in the graphs fits the relationship between ESG and crash risk. We can see a non-monotonic relationship

[17] We put another measure of crash risk and the corresponding Pearson coefficient in parentheses.

in both pictures though it is not so obvious. The curve is an intuitive confirmation of our hypothesis. In the next section, we explore the relationship statistically.

[Figure 3]

6.2 Effect of ESG on crash risk

Table 5 shows the regression results of the relationship between ESG and crash risk with controlling other probable determining factors of crash risk. From the results in Table 5, we can see that the linear relationship in columns (1) and (2) (whether the dependent variable shows as F_NCSKEW or F_DUVOL) is not significant, which means the association between ESG and crash risk is not liner. This finding is inconsistent with many studies that have verified a negative connection between ESG and crash risk (Kim et al., 2014; Feng et al., 2021). It is also contradictory to Dai et al. (2019), which proved an inverted U-shaped relationship between CSR and crash risk. The results in columns (3) and (4) in table 5 present that the coefficient of the ESG quadratic term is significantly positive and the coefficient of ESG is significantly negative. This means the link between ESG and predicted crash risk(in one year) (represented as F_NCSKEW and F_DUVOL) is non-monotonic. Column (3) indicates that when ESG increases, the crash risk in the next year first decreases and then increases afterward. The critical point appears when the ESG score is about 20.91 (that is when the natural logarithm of ESG score equals about 3.04). Column (4) also indicates the relationship, which first goes down and then up. The critical point in column (2) appears when the ESG score is about 20.70 (that is, when the natural logarithm of ESG score equals about 3.03), which is very similar to column (1). Comparably, the mean and median values of the ESG score are 21.88 and 21.07, respectively. Therefore, the critical point is very close to the mean and median values.

As shown in previous studies, in developed countries, the negative relationship shows that the higher the ESG level, the more transparent the company's information, and the lower the risk of stock crashes. However, in developing countries, such as China, ESG development is at an early stage, and the situation is different. Here, the ESG disclosure and regulatory systems are immature. At the same time, due to the country's emphasis on sustainable development, companies are likely to achieve their personal goals by presenting high-level ESG information to the public. Therefore, the higher ESG level here may not mean that the company's information is transparent and the available stakeholder advantages, but it hides serious agency problems, which increases the risk of stock crashes. As to the control variables, MB and Ret are significantly and positively correlated with crash risk, while Sigma is significantly and negatively related to crash risk. The coefficients of the control variables are consistent

with previous studies. (Kim et al., 2014; Dai et al., 2019).

However, the criterion of a significant quadratic term is weak. The problem arises when the true relationship is convex but monotone over relevant data values. A quadratic specification may then erroneously yield an extreme point.[18] Lind and Mehlum (2010) put forward "utest" (a test in STATA) to provide the exact test of the presence of a turning point on an interval. This test first calculates the location of the extreme point according to the regression equation and then divides the whole data into the data before and after the extreme point. After that, it checks whether the first part of the data is monotonically downward and whether the latter part is monotonically upward. The null hypothesis for this test is "monotone or inverse U-shape". After performing the utest, we obtain the values of the t-value and P-value, 1.56 and 0.0703, respectively. The null hypothesis is rejected at a 10% confidence level. Overall, the results in table 5 present that the relationship between ESG and crash risk is non-monotonic, which means an appropriate ESG disclosure, rather than a too-low or too high-ESG score, is most beneficial to maintaining the stock price stable.

[Table 5]

6.3 Endogeneity

The preliminary result shows a non-monotonic link between ESG and one-year-ahead firm-specific stock price crash risk. However, considering the potential endogeneity problems is necessary. Endogeneity may arise due to unobservable firm-specific factors which affect both ESG and crash risk at the same time. Our estimation model uses the lagged ESG score to predict the following year's crash risk. This could potentially mitigate endogeneity concerns named reverse causality. The simultaneity concern remains since the ESG scores are very sticky over the sample years. Thus, we conduct the instrumental variables method to estimate the model.

According to the prior research (e.g., (Kim et al., 2014)), we select the average ESG score of the other firms in the same industry as the instrumental variable.[19] This instrumental variable satisfies both relevance and exogenous restrictions: first, the average ESG score of all other firms in the same industry is usually related to this firm's ESG; on the other hand, the ESG of other firms cannot affect the crash risk of this firm. We have performed relevant tests to show that the instrumental variables are appropriate. For the endogeneity test: The P values of the Durbin-Wu-Hausman

[18]Specifically, given that the true relationship of the two variables is monotonically increasing (or monotonically decreasing) when we add a quadratic term to the regression, this may generate an unreal extreme point, presenting a falsely significant quadratic term.

[19]The classification of the industries refers to the "China 2012 Industry Classification Standard" issued in 2012.

test were zero, rejecting the null hypothesis that $lnESG$ and $lnESG^2$ are exogenous variables. For the weak instrumental variable test: The first-stage F values are around 362 and 431, indicating that there are significant correlations between instrumental variables and endogenous explanatory variables.[20]

The result of the instrumental variables method is shown in Table 6. For the first stage (Columns (1) and (2)), we consider two endogenous variables, namely, $lnESG$ and $lnESG^2$. For this reason, two IVs, $IV\_(lnESG)$ and $IV\_(lnESG^2)$ are used. Here, $IV\_(lnESG)$ is the natural logarithm of the average ESG of all other firms in the same industry. $IV\_(lnESG^2)$ is the square of $IV\_(lnESG)$. For both $lnESG$ equation and $lnESG^2$ equation, we have used both $IV\_(lnESG)$ and $IV\_(lnESG^2)$. We control "Control" for both equations at the first stage. The control variables used in both equations are the same and also the same as those used in the second stage. For the second stage (Columns (3) and (4)), we use two dependent variables, F_NCSKEW and F_DUVOL, for robustness. The first stage results indicate that the instrumental variable is significantly positively related to the $lnESG$ and $lnESG^2$. The third and fourth columns are significant and consistent with the baseline findings. Therefore, the non-monotonic relationship still holds after addressing the endogeneity concerns via the instrumental variable method.

[Table 6]

6.4 Robustness test

Several robustness tests have been conducted to ensure the results' reliability. First, we use two indicators, $NSKEW$ and $DUVOL$, to measure stock price crash risk, and we find the results consistent between these two in all tables. Second, since ESG contains social responsibility and environmental responsibility, the ESG engagement of dirty industries[21] will have a greater impact on their firm value. Therefore, we divided the research samples into dirty and clean industries to conduct regression. From Table 7, we can see that the quadratic relationship between ESG and crash risk exists in dirty industries, but not in other industries. This suggests that ESG can significantly impact company value in industries where ESG engagement is more important, like dirty industries. According to the 2012 version of the industry classification of listed companies, we classify B (mining industry), C (manufacturing industry), D (electricity, heat, gas, and water production and supply industry) as dirty industries, and other industries as clean industries.

[Table 7]

[20] Both of the two F values have a P value of zero.

[21] We refer to heavy-polluting industries as dirty industries.

We divided the samples into manufacturing (generally considered more pollution-carrying) and non-manufacturing industries to conduct regression, respectively, and the results are shown in Table 8. From Table 8, we can see that the quadratic relation between ESG and crash risk exists in the manufacturing industry but not in other industries. This suggests that ESG can significantly impact company value in industries where ESG engagement is more important, like manufacturing.

[Table 8]

Third, we divided the research samples into two parts, whether recent years or not (we took the recent five years as recent years) and presented the results in Table 9. As ESG investment is increasingly valued in China, ESG engagement has likely had a more significant impact on firm value in recent years than before. From the results in Table 9, we can see that the quadratic correlation between ESG and crash risk exists only in the sample data after 2015, regardless of whether NSKEW or DUVOL is taken as the dependent variable. This result shows that as the public attaches more importance to ESG (environmental responsibility, social responsibility, corporate governance) engagement in recent years, the company's ESG performance significantly impacts the firm value.

[Table 9]

7 Conclusion

Sustainable development is becoming more and more important nowadays. As an important part of the economy and society, to improve their competitiveness in the fierce market and achieve sustainable development while pursuing profit, enterprises must actively conduct their ESG engagement. As China has focused more on sustainable development at all levels of the country in recent decades, it is of great significance for Chinese-listed enterprises to fulfill their ESG.

This paper examines the effect of ESG disclosure on firm-specific stock price crash risk. This is a meaningful problem as a business invest a lot in ESG event and wish to earn some benefits from ESG engagement. Previously, there are two mainstream rival claims on this relationship. On the one hand, ESG disclosure equals a high degree of transparency in financial reporting, which is found significantly reduce crash risk by previous studies in financial transparency (e.g. Lowenstein, 1996). Thus, ESG is expected to reduce the stock price crash risk (e.g., negatively related). On the other hand, ESG disclosure is also viewed as an expectation management tool (moral hazard problem), a sign of hypocrisy of managers who may hide bad news and even grasp benefits for their private interest. In this case, ESG may increase the stock price crash risk (e.g., positively related). Each theory received empirical support from previous

research, leading to a controversial pending problem.

This paper tries to solve the problem quantitatively. We first develop an analytical model to cover dominant variables in both theories and establish an important result that the relationship overall is non-monotonic. Specifically, a low ESG level should decrease crash risk, while a high ESG level does the contrary. This insight is very useful and solid, yet insufficient to give a specific function form. Therefore, we further use reduced-form analysis to derive a non-monotonic curve. Using the Chinese A-share listed firms during the year 2006-2020 as a sample, we find that there is a non-monotonic relationship between ESG and crash risk, and the relationship holds after controlling other impacting factors. In addition, our results remain robust after considering potential endogenous problems using the IV method. This finding means that the discretional exposure of ESG information has a complicated connection with firm-specific stock price crash risk. Specifically, as the firm discloses more ESG information, its stock price crash risk first decreases and increases afterward.

Our study adds to the growing ESG literature in two senses. First, this paper expands the scope of ESG research as we introduce an analytical model instead of pure empirical evidence. This offers us more insight into the mechanism and can bring about counterfactual knowledge. Second, our empirical finding of the non-monotonic curve is novel and robust. This finding coincides with our analytical result using data from Chinese listed companies. There are some implications for the manager, investor, policymaker, and other relevant agents. For the manager, it is important to conduct ESG engagement at an appropriate level since it can not only help enhance the firm's reputation but also help keep the stock price stable. For the investor, it is possible to choose firms with appropriate ESG to score rather than too low or too high to invest, to reduce the potential damage that may cause by the stock price crash to personal interests. For the policymaker, making regulations encouraging companies with low ESG scores to disclose more ESG information can help reduce the volatility in the stock market.

This study still has some limitations. First, the ESG score in this study was measured by the evaluation index of the third-party rating agency. Albeit it seems appropriate and is generally accepted by academics, the index still has some deficiency in reflecting the actual ESG performance of listed firms in China. Since the ESG score is attained based on the ESG information disclosed by the firms, the rating agencies have not evaluated the actual ESG performance of the listed firms. The advanced measurement method is necessary to be carried out for more credible results. Second, the sample only contains the listed firm disclosing the ESG information. It is not a high percentage compared to all the listed firms; thus, the evaluation index can not fully reflect the ESG performance of all Chinese listed firms. More firms with ESG

disclosure will help ease this problem in the future.

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Table 1: Variable definition

Variables	Definition	Source
Crash risk variables		
NCSKEW	The negative coefficient of skewness. See Eq. (25) for details.	Calculated by the authors
DUVOL	The down-to-up volatility. See Eq. (26) for details.	Calculated by the authors
Key independent variables		
ESG	ESG score	Bloomberg
Firm-level control variables		
SIZE	measured as the natural log of a firm's total assets	CSMAR
ROA	measured as the income before extraordinary items divided by total assets	CSMAR
MB	measured as the ratio of the firm's market value to the book value	CSMAR
LEV	measured as the total liability scaled by total assets	CSMAR
Sigma	the standard deviation firm-specific weekly return over the fiscal year	Calculated by the authors
Ret	the average firm-specific weekly return over the fiscal year	Wind
DTURN	the detrended stock trading volume, calculated as the average monthly share turnover for the current fiscal year minus the average monthly share turnover for the previous fiscal year	Wind
ABACC	The absolute value of discretionary accruals, where discretionary accruals are estimated from the modified Jones model (Dechow et al., 1995).	Calculated by the authors

Table 2: Sample distribution

Year	Frequency	Percent	ESG	NCSKEW	DUVOL
2005	4	0.06	12.293	0.175	0.111
2006	12	0.18	14.910	-0.438	-0.316
2007	28	0.41	15.507	-0.222	-0.116
2008	216	3.19	19.413	-0.039	-0.019
2009	277	4.09	20.652	-0.498	-0.370
2010	297	4.38	21.275	-0.138	-0.122
2011	429	6.33	21.826	-0.229	-0.156
2012	585	8.63	20.766	-0.243	-0.152
2013	642	9.47	20.885	-0.420	-0.270
2014	638	9.41	21.113	-0.426	-0.288
2015	710	10.48	21.584	-0.282	-0.207
2016	671	9.9	22.280	-0.542	-0.382
2017	728	10.74	22.826	-0.190	-0.123
2018	794	11.72	23.363	-0.108	-0.092
2019	746	11.01	23.542	-0.437	-0.299
Total	6777	100	21.881	-0.309	-0.214

Note: This table shows the sample size and mean values of ESG and crash risk measures by year. The sample includes 6777 firm-year observations from 2005 to 2019.

Table 3: Descriptive statistics

VarName	Obs	Mean	SD	Min	Median	Max
F_NCSKEW	6777	-0.342	0.725	-5.170	-0.296	3.736
F_DUVOL	6777	-0.235	0.481	-2.046	-0.235	2.239
ESG	6777	21.881	5.284	9.091	21.074	61.722
NCSKEW	6777	-0.309	0.721	-5.170	-0.271	3.736
LEV	6777	0.491	0.197	0.008	0.502	1.698
SIZE	6777	23.095	1.266	19.541	23.018	28.341
DTURN	6777	0.042	0.138	-0.746	0.000	0.770
MB	6777	2.133	1.608	0.692	1.631	30.674
ROA	6777	0.046	0.065	-0.902	0.039	0.590
Ret	6777	0.003	0.010	-0.038	0.002	0.075
Sigma	6777	0.059	0.024	0.015	0.054	0.232
ABACC	6777	0.053	0.052	0.000	0.037	0.470

Note: This table reports the descriptive statistics of all variables. The data ranges from 2005 to 2019 for ESG and control variables and from 2006 to 2020 for crash risks.

Table 4: Pearson correlation matrix

	F_NCSKEW	F_DUVOL	ESG	NCSKEW	DUVOL	LEV	SIZE	DTURN	MB	ROA	Ret	Sigma	ABACC
F_NCSKEW	1												
F_DUVOL	0.876***	1											
ESG	-0.003	-0.008	1										
NCSKEW	0.072***	0.070***	0.001	1									
DUVOL	0.064***	0.060***	-0.007	0.878***	1								
LEV	-0.066***	-0.076***	0.089***	-0.080***	-0.089***	1							
SIZE	-0.059***	-0.082***	0.364***	-0.074***	-0.097***	0.493***	1						
DTURN	0.005	0.009	-0.048***	0.038***	0.035***	-0.032***	-0.059***	1					
MB	0.151***	0.148***	-0.145***	0.095***	0.085***	-0.450***	-0.445***	0.044***	1				
ROA	0.117***	0.111***	-0.007	0.109***	0.100***	-0.474***	-0.106***	0.058***	0.436***	1			
Ret	0.068***	0.058***	-0.042***	-0.168***	-0.186***	-0.024**	-0.089***	0.018	0.375***	0.117***	1		
Sigma	-0.067***	-0.077***	-0.135***	-0.088***	-0.086***	0.039***	-0.219***	0.003	0.264***	-0.100***	0.394***	1	
ABACC	0.016	0.014	-0.073***	0.025**	0.012	0.053***	-0.063***	-0.014	0.084***	0.012	0.003	0.095***	1

Note: This table reports the correlation coefficients of each variable in our main regression. All correlation coefficients are below 0.8 (except the correlation coefficients of similar measures), indicating no significant multi-collinearity problem exists. * denotes $p < 0.1$, ** $p < 0.05$, and *** $p < 0.01$.

Table 5: Regression analysis on the effect of ESG on crash risk

	(1) F_NCSKEW	(2) F_DUVOL	(3) F_NCSKEW	(4) F_DUVOL
$lnESG$	0.024	0.019	-0.845**	-0.632*
	(0.86)	(0.80)	(-2.27)	(-1.98)
$lnESG^2$			0.139**	0.104*
			(2.47)	(2.11)
NCSKEW	0.059*		0.059*	
	(1.93)		(1.93)	
DUVOL		0.046**		0.046**
		(2.66)		(2.63)
LEV	0.018	0.012	0.018	0.012
	(0.25)	(0.24)	(0.25)	(0.24)
SIZE	0.007	-0.005	0.006	-0.006
	(0.26)	(-0.29)	(0.24)	(-0.32)
DTURN	-0.025	-0.005	-0.027	-0.006
	(-0.36)	(-0.13)	(-0.39)	(-0.16)
MB	0.052***	0.033***	0.051***	0.033***
	(6.01)	(5.09)	(5.98)	(5.06)
ROA	0.164	0.072	0.163	0.071
	(0.73)	(0.44)	(0.73)	(0.43)
Ret	9.733***	6.448***	9.720***	6.438***
	(3.70)	(3.40)	(3.70)	(3.39)
Sigma	-0.714	-0.847*	-0.722	-0.853*
	(-0.82)	(-1.81)	(-0.83)	(-1.81)
AbsDA	-0.018	-0.019	-0.022	-0.022
	(-0.16)	(-0.20)	(-0.19)	(-0.24)
Constant	-0.352	0.081	0.974	1.075*
	(-0.58)	(0.18)	(1.61)	(1.98)
Industry	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
N	6777	6777	6777	6777
adj. R2	0.091	0.090	0.091	0.090
F	2659.527	3145.522	106.443	157.664

Note: This table reports regression results of the impact of ESG scores on the probability of firm-level stock crash risk. The sample covers 6777 firm-year panel observations from 2006 to 2019. Notice that the two-tailed t-values, based on standard errors modified by a two-dimensional cluster at the firm and year levels, are disclosed in parentheses. * denotes $p < 0.1$, ** denotes $p < 0.05$, and *** denotes $p < 0.01$.

Table 6: Regression analysis to address endogeneity concerns

	(1)	(2)	(3)	(4)
	First1	First2	Second1	Second2
Dep. Var.	$lnESG$	$lnESG^2$	F_NCSKEW	F_DUVOL
$IV\_(lnESG)$	0.164***	-6.497***		
	(4.04)	(-3.72)		
$IV\_(lnESG^2)$	-0.044	2.032***		
	(-0.17)	(7.24)		
$(lnESG)\_HAT$			-6.305*	-4.551*
			(-1.69)	(-1.79)
$(lnESG^2)\_HAT$			1.050*	0.750*
			(1.74)	(1.83)
NCSKEW			0.056***	
			(4.39)	
DUVOL				0.043***
				(3.34)
LEV	-0.095***	-0.597***	0.043	0.025
	(-2.99)	(-3.11)	(0.65)	(0.55)
SIZE	0.061***	0.388***	-0.014	-0.018
	(9.71)	(8.97)	(-0.89)	(-1.64)
DTURN	-0.030	-0.178	-0.029	-0.009
	(-1.26)	(-1.22)	(-0.45)	(-0.21)
MB	-0.007**	-0.043**	0.051***	0.032***
	(-2.77)	(-2.68)	(5.92)	(5.47)
ROA	-0.068	-0.420	0.161	0.070
	(-1.35)	(-1.36)	(0.81)	(0.51)
Ret	1.632***	10.309***	9.152***	6.113***
	(4.45)	(4.49)	(5.85)	(5.72)
Sigma	-0.479***	-2.949**	-0.679	-0.838*
	(-2.98)	(-2.91)	(-1.06)	(-1.92)
AbsDA	-0.067	-0.396	-0.031	-0.031
	(-1.51)	(-1.46)	(-0.18)	(-0.27)
Constant	0.404	2.252	9.371	7.089*
	(1.35)	(1.11)	(1.64)	(1.82)
Industry	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
N	6777	6777	6777	6777
F	362	431		

Note: This table shows the regression result after dealing with endogeneity issues on the effect of ESG scores on crash risk. Columns (1) and (2) present the first-stage results of the instrumental variable method, and columns (3) and (4) report the second-stage results of the instrumental variable method. The two-tailed t values, based on standard errors modified by a two-dimensional cluster at the firm and year levels, are disclosed in parentheses.. * denotes p < 0.1, ** denotes p < 0.05, and *** denotes p < 0.01.

Table 7: Regression analysis: dirty vs clean industries

	(1)	(2)	(3)	(4)
	F_NCSKEW		F_DUVOL	
	clean	dirty	clean	dirty
$lnESG$	-1.075	-0.732	-0.320	-0.694*
	(-1.12)	(-1.72)	(-0.51)	(-1.99)
$lnESG^2$	0.166	0.123*	0.049	0.115**
	(1.07)	(1.93)	(0.46)	(2.17)
NCSKEW	0.081*	0.047		
	(1.84)	(1.70)		
DUVOL			0.051	0.042**
			(1.38)	(2.49)
LEV	0.295**	-0.073	0.213***	-0.053
	(2.95)	(-0.76)	(2.98)	(-0.95)
SIZE	-0.006	0.011	-0.017	-0.001
	(-0.23)	(0.37)	(-1.01)	(-0.07)
DTURN	0.070	-0.067	0.039	-0.024
	(1.35)	(-0.68)	(0.95)	(-0.50)
MB	0.069***	0.046***	0.042***	0.030***
	(3.50)	(6.67)	(3.24)	(5.63)
ROA	0.289	0.135	0.305	0.003
	(1.07)	(0.57)	(1.02)	(0.01)
Ret	10.826**	9.288***	7.268***	6.094**
	(2.97)	(3.40)	(3.60)	(2.96)
Sigma	-0.418	-0.992	-0.762	-0.986**
	(-0.27)	(-0.97)	(-0.74)	(-2.68)
AbsDA	-0.127	0.006	-0.046	-0.021
	(-0.57)	(0.04)	(-0.22)	(-0.17)
Constant	1.259	0.647	0.578	1.006
	(1.19)	(1.08)	(0.89)	(1.40)
Industry	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
N	1980	4797	1980	4797
adj. R2	0.093	0.096	0.090	0.097
F	510.366	317.316	2111.252	1078.668

Note: This table shows the regression result of the effect of ESG on crash risk in dirty and clean industries. Columns (1) and (2) present the results of the dependent variable F_NCSKEW, and columns (3) and (4) report the results of the dependent variable F_DUVOL. The two-tailed t values, based on standard errors modified by a two-dimensional cluster at the firm and year levels, are disclosed in parentheses. * denotes $p < 0.1$, ** denotes $p < 0.05$, and *** denotes $p < 0.01$.

Table 8: Regression analysis: manufacture vs other industries

	(1)	(2)	(3)	(4)
	F_NCSKEW		F_DUVOL	
	others	manufacture	others	manufacture
$lnESG$	-0.718	-0.909*	-0.394	-0.782*
	(-0.81)	(-1.81)	(-0.52)	(-1.83)
$lnESG^2$	0.118	0.148*	0.067	0.127*
	(0.80)	(1.99)	(0.52)	(1.95)
NCSKEW	0.064	0.055*		
	(1.49)	(2.12)		
DUVOL			0.045	0.046**
			(1.38)	(2.75)
LEV	0.161**	-0.059	0.110**	-0.037
	(2.19)	(-0.52)	(2.21)	(-0.62)
SIZE	0.003	0.009	-0.008	-0.005
	(0.11)	(0.31)	(-0.41)	(-0.26)
DTURN	-0.016	-0.034	-0.023	0.002
	(-0.17)	(-0.42)	(-0.31)	(0.05)
MB	0.078***	0.042***	0.046***	0.028***
	(3.78)	(7.04)	(3.56)	(5.44)
ROA	0.095	0.202	0.113	0.054
	(0.37)	(0.84)	(0.51)	(0.30)
Ret	11.128***	9.011***	6.839***	6.238***
	(3.35)	(3.69)	(3.46)	(3.39)
Sigma	-1.464	-0.315	-1.329*	-0.614
	(-1.58)	(-0.22)	(-2.02)	(-1.01)
AbsDA	-0.032	-0.017	0.016	-0.041
	(-0.13)	(-0.10)	(0.08)	(-0.39)
Constant	0.962	0.596	0.766	1.095
	(0.85)	(0.57)	(0.81)	(1.27)
Industry	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
N	2698	4079	2698	4079
adj. R2	0.083	0.102	0.078	0.106
F	666.117	2226.738	694.626	1125.902

Note: This table shows the regression result of the effect of ESG scores on crash risk in different industries (manufacture or not). Columns (1) and (2) present the results of the dependent variable F_NCSKEW, and columns (3) and (4) report the results of the dependent variable F_DUVOL. The two-tailed t values, based on standard errors modified by a two-dimensional cluster at the firm and year levels, are disclosed in parentheses. * denotes $p < 0.1$, ** denotes $p < 0.05$, and *** denotes $p < 0.01$.

Table 9: Regression analysis: recent vs previous years

	(1)	(2)	(3)	(4)
	F_NCSKEW		F_DUVOL	
	previous	recent	previous	recent
$lnESG$	0.204	-1.072*	0.264	-0.924***
	(0.23)	(-2.16)	(0.31)	(-7.32)
$lnESG^2$	-0.029	0.163*	-0.039	0.143***
	(-0.19)	(2.23)	(-0.26)	(6.81)
NCSKEW	0.063**	0.039		
	(2.79)	(0.88)		
DUVOL			0.049*	0.028
			(2.19)	(1.71)
LEV	0.061	-0.014	0.003	0.028
	(0.71)	(-0.13)	(0.05)	(0.41)
SIZE	-0.036	0.061***	-0.030	0.026*
	(-1.21)	(5.99)	(-1.32)	(2.42)
DTURN	-0.075	0.032	-0.008	-0.008
	(-0.74)	(0.38)	(-0.14)	(-0.10)
MB	0.044**	0.062***	0.029**	0.040***
	(2.91)	(19.34)	(2.78)	(39.72)
ROA	0.705***	-0.172*	0.441**	-0.189*
	(4.61)	(-2.63)	(2.81)	(-2.67)
Ret	8.486*	9.644**	5.581	6.946**
	(1.85)	(3.71)	(1.66)	(4.05)
Sigma	0.310	-0.869	0.012	-1.119
	(0.25)	(-0.66)	(0.02)	(-1.64)
AbsDA	-0.100	0.009	-0.054	-0.016
	(-0.88)	(0.05)	(-0.57)	(-0.09)
Constant	0.359	0.739	0.286	1.432***
	(0.35)	(1.97)	(0.30)	(6.50)
Industry	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
N	3128	3649	3128	3649
adj. R2	0.114	0.101	0.112	0.100
F	789.283	43.355	2014.699	54.619

Note: This table shows the regression result of the effect of ESG scores on crash risk in different years (recent years from 2015-2019 or not). Columns (1) and (2) present the results of the dependent variable F_NCSKEW, and columns (3) and (4) report the results of the dependent variable F_DUVOL. The two-tailed t values, based on standard errors modified by a two-dimensional cluster at the firm and year levels, are disclosed in parentheses. * denotes $p < 0.1$, ** denotes $p < 0.05$, and *** denotes $p < 0.01$.

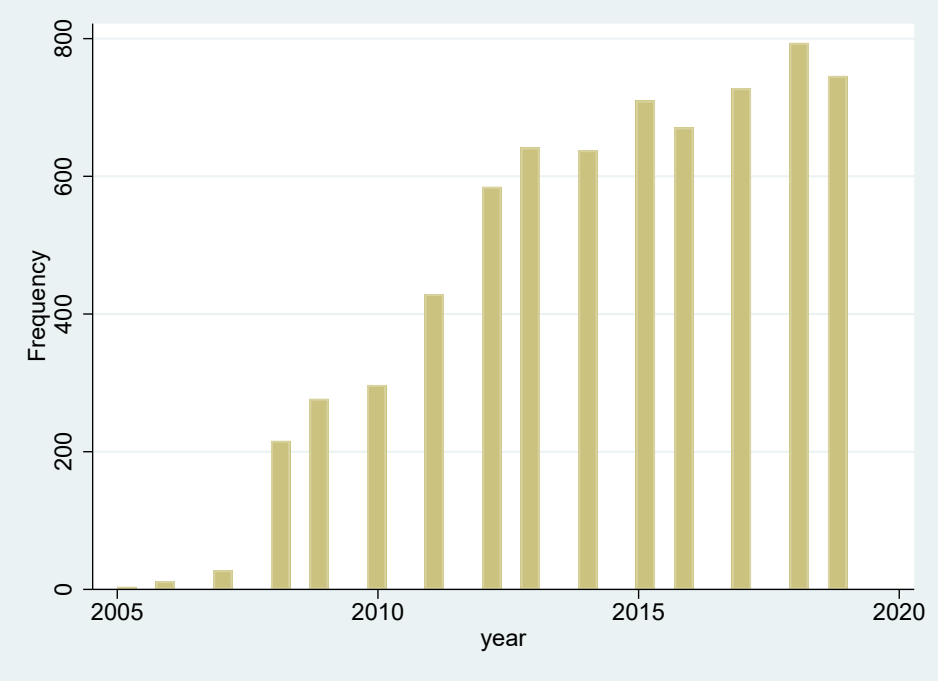

Figure 1: The number of firms with ESG disclosure in each year

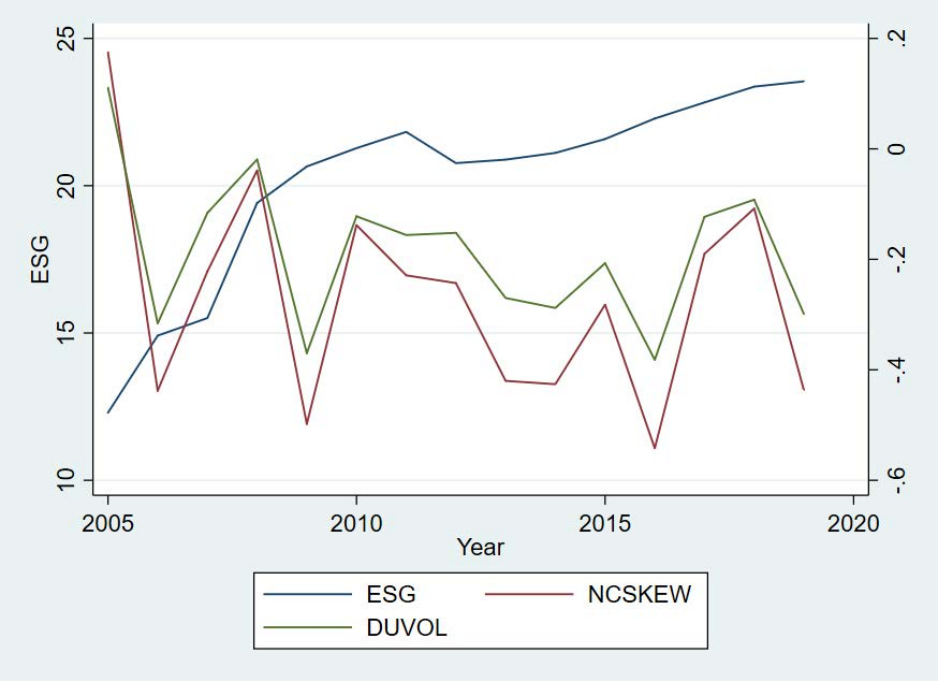

Figure 2: The values of ESG, NCSKEW, and DUVOL over the year

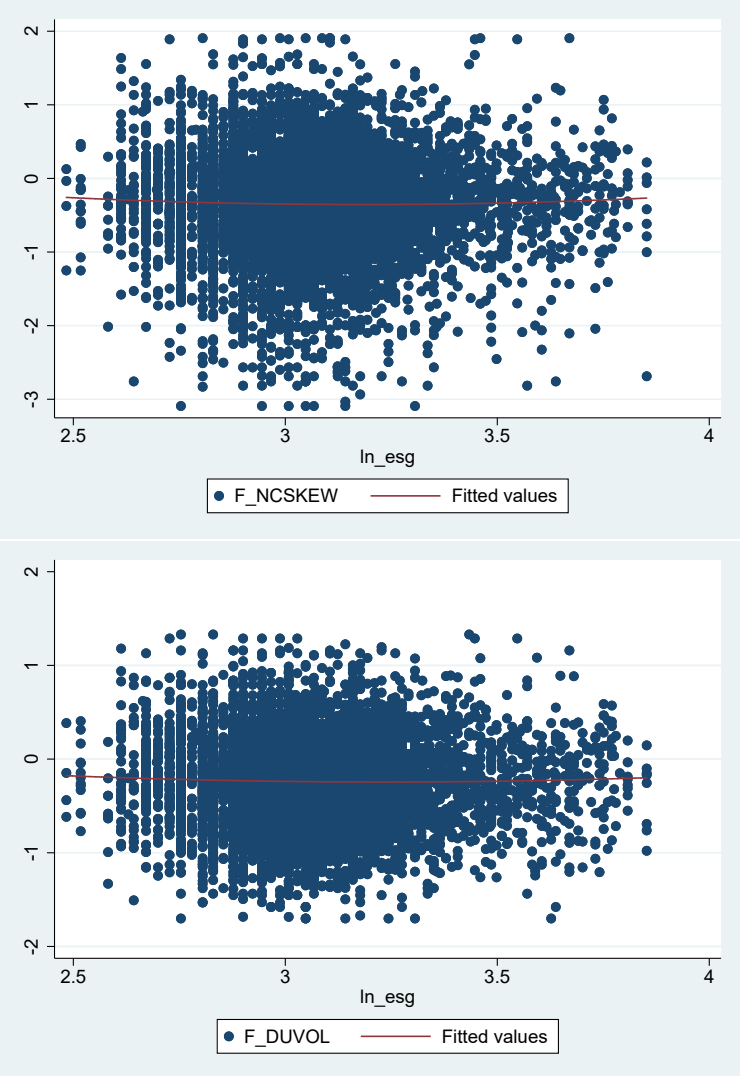

Figure 3: The relationship between ESG disclosure and crash risk