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Managing crash risks through supply chain transparency: evidence from China

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Abstract

Using data on Chinese non-financial listed firms covering 2009 to 2022, we explore the effect of supply chain transparency on stock price crash risk. Two proxies for supply chain transparency are constructed using the number of supply chain partners' names and the proportion of their transactions disclosed in annual reports. The results reveal that enhancing supply chain transparency can decrease crash risk, specifically by mitigating tax avoidance and earnings management. Moreover, the analysis suggests that this risk-reduction effect is more prominent in companies where managers are more incentivized to hide negative information and investors possess superior abilities to acquire information. Interestingly, supplier transparency is more influential in mitigating crash risk than customer transparency. These findings emphasize the significance of supply chain transparency in managing financial risk.

Keywords: Supply chain transparency, Stock price crash risk, Corporate governance, Information transfer

JEL Classification: G30, G32, M14

Introduction

Inter-firm economic connections have become increasingly complex, with supplier-customer relationships being of significant importance. Recent high-profile cases, such as Luckin Coffee's delisting, highlight the damaging effects of fraudulent transactions with related parties in supply chains. NMC Health PLC. (Arabic: مستشفى المركز الطبي الجديد) was also accused of manipulating its financial statements through undisclosed related-party transactions and inflated asset values. Complex supply chain activities make it easy for companies to conceal negative news by fabricating sales information or manipulating supply chain costs, resulting in substantial wealth loss for investors once exposed (Lanier et al. 2019; Richardson et al. 2022). Given the growing significance of supply chain transparency (SCT), it is imperative to investigate its potential impact on financial risk management.

SCT refers to the practice of a company sharing information with the public, involving consumers and investors regarding its upstream operations and the products it offers to consumers. This entails providing detailed information about the various stages of the supply chain, such as sourcing, manufacturing, and distribution, and the environmental

and social impacts associated with these processes. Firms' cash flows are intricately linked to their supply chains, with profits generated from suppliers' purchases and customer sales. Accordingly, their earning status is also reflected in their suppliers' or customers' sales revenue and procurement costs (Guo et al. 2023; Pandit et al. 2011; Liu et al. 2024). Thus, understanding their partners better can help reduce information asymmetry and uncover opportunistic behavior within firms. Despite the importance of SCT, its impact on corporate behavior remains largely unknown.

Stock price crash risk pertains to the extreme negative skewness in the distribution of firm-specific stock returns (Zhang et al., 2024; Chen et al. 2001). In information asymmetry situations, managers may prioritize their interests by withholding or stalling the disclosure of negative information. Its accumulation can eventually exceed the market's acceptance threshold, resulting in a rapid and substantial release of bad news, which can cause a significant decline in a firm's stock price, ultimately leading to a crash (Jin & Myers 2006; Dewally & Shao 2013). Using this analytical framework, researchers have evaluated the determinants of crash risk, such as managerial incentives, reporting quality, tax avoidance, analyst coverage, and institutional ownership (Kim et al. 2019a, b; Kim et al. 2011a, 2011b, 2019a, b). Despite these efforts, the effect of supply chain information on such risks has not received much attention.

The literature most closely related to this study examines the correlation between supply chain relationships and crash risk. Notably, Lee et al. (2020) and Ma et al. (2020) conducted thorough investigations into this matter, revealing that higher customer concentration is linked to an increased risk of such crashes. Moreover, Cao et al. (2022) shed light on the proximity of large customers in mitigating crash risk for suppliers, whereas Shi et al. (2022) examined the positive effect of supply chain network centrality in this context. However, the impact of a supply chain's information environment has received relatively little attention.

Previous studies have presented two opposing hypotheses on the correlation between SCT and crash risk. Supply chain transparency can mitigate crash risks. Providing supply chain information enables stakeholders to assess a company's sales and purchasing activities and the stability of its relationships with upstream and downstream partners along the supply chain. Such information is crucial in determining a company's future cash flow, profitability, and other key indicators. It can be utilized by investors and analysts to reduce information asymmetry and prevent managers from concealing negative information (Luo & Nagarajan 2015). However, SCT may amplify crash risk. If a company's supply chain information is obtained from its competitors, it faces the risk of having its transaction contract information and trade secrets stolen or even losing major customers or suppliers (You et al., 2024; Ellis et al. 2012; Li et al. 2018; Tiwari et al. 2023). Macready et al. (2020) also find that managers may strategically disclose positive information while withholding bad news along the supply chain, leading to a cumulative build-up of crash risk. Thus, the impact of SCT on crash risk is a subject that needs empirical investigation, as it is contingent upon a delicate balance between mitigating information asymmetry and the associated proprietary costs.

To bridge this gap, we examine the impact of SCT on the crash risk of nonfinancial Chinese listed firms from 2009 to 2022. By developing two proxies for SCT based on the reported names and transaction proportions of supply chain partners, we provide novel

evidence of the effect of SCT on financial risks. Our findings reveal that enhancing SCT can help mitigate crash risk by reducing tax avoidance and earnings management. The results indicate supplier transparency plays a more critical role than customer transparency in mitigating risks. Moreover, our analysis illustrates that the benefits of SCT are more pronounced in firms with higher managers' incentives to conceal bad news and in investors with better information acquisition abilities.

This study expands the existing literature in several ways. First, while prior evidence has predominantly focused on the determinants of crash risk such as human capital, ESG ratings, digital transformation, and causal language intensity (Pan et al., 2024; Calen & Fang 2015; Feng et al. 2022; Jiang et al. 2022; Kong et al. 2021), we uniquely explore the origins of this phenomenon through the lens of SCT. Second, we provide novel evidence for SCT. Despite increasing evidence on the importance of SCT, research on this topic still lags behind other corporate finance themes and lacks sufficient practical and theoretical significance (Li & Wang 2016; Li et al. 2022; Montecchi et al. 2021; Yahya & Lee 2023). We uncover a potential mechanism by examining two competing hypotheses on the correlation between SCT and crash risk. Third, although business transactions between firms and their supply chain partners significantly influence a firm's information environment, there is an ongoing debate over whether the government should push for increased supply chain disclosures (She 2022). We provide crucial evidence for businesses and regulatory agencies by highlighting the positive role of SCT and the interplay between corporate governance and information environments in preventing financial risks.

The rest of this paper is structured as follows: Sect. "Literature review and hypothesis development" provides a literature review and presents the formulated hypotheses. Sect. "Methods and data" outlines the methods and variables used in this study. Sect. "Empirical results and analysis" analyses the results of the baseline regression and robustness tests. Sect. "Further analysis" validates the proposed impact mechanism. Finally, the study concludes and provides implications.

Literature review and hypothesis development

Literature review

The literature relevant to our research examines the correlation between supply chain characteristics and firms' decision-making. Supply chain concentration affects various aspects, such as risk-taking, search behavior, and merger and acquisition performance (Cao et al. 2021; Dong et al. 2021; Zhong et al. 2021). Information shared along the supply chain has spillover effects because suppliers and customers play significant roles. Stakeholders, including investors and analysts, can use this complementary information to make informed decisions and provide accurate performance predictions for target firms. Specifically, analysts who track a firm's customers can obtain informative news and provide more accurate profit forecasts (Guan et al. 2015; Lee and Yuan 2024), while the disclosure of customer earnings announcements can correct investors' expectations of a firm's cash flow and earnings (Pandit et al. 2011). Such information disclosure has significant economic consequences, which have been studied previously. By disclosing information regarding supply chain production practices and ethics, companies can alleviate regulatory pressure from authorities (Gualandris et al. 2015; Shi et al. 2021) She

et al., 2022) while also fostering trust and long-term cooperation with customers and suppliers (Villena & Dhanorkar 2020). This can also attract talent, potential partners, and valued investors. However, scholars have noted that disclosing supply chain information may result in the leakage of competitive advantages and vulnerabilities, leading to adverse reactions from stakeholders. For example, Tang et al. (2022) found that investors perceive increased future business risks for companies when they disclose information about their five largest customers, as reflected in lower long-term earnings response coefficients.

Another category of related literature pertains to crash risk, which arises from the management's tendency to withhold bad news, leading to its accumulation (Liu et al. 2023a; Lee et al. 2024). In an environment characterized by information asymmetry and management incentives, the likelihood of withholding negative information is significant, and its detection can be challenging (Kim et al. 2011a, 2011b; Jin et al. 2022). Earlier studies establish that corporate governance is critical for mitigating crash risk. In contrast, recent studies emphasize the growing importance of other factors such as industry structure (Li & Zhan 2019), brand capital (Hasan et al. 2022), COVID-19 (Huang & Liu 2021), gambling preferences (Ji et al. 2021) CEO inside debt (Lee et al. 2023a) and regulation (Lu & Qiu 2023). Amid these developments, researchers have increasingly focused on the role of supplier-customer relationships in managing risks. According to Lee et al. (2020) and Ma et al. (2020), customer concentration results in the accumulation of bad news, thereby increasing the risk of collapse. Moreover, Cao et al. (2022) reveal that the geographic proximity of large customers mitigates the crash risk for suppliers.

It is widely acknowledged that supply chain partners are crucial stakeholders of a firm, and their characteristics significantly impact its costs and benefits. Correspondingly, information transfer among transaction partners influences a firm's operational decision-making. Nonetheless, most current evidence concentrates on the influence of customer or supplier information disclosure on a firm's crash risk (Guan et al. 2015; Pandit et al. 2011; Wang & Lee 2023), with limited knowledge of the effect of voluntary supply chain disclosure on its associated risk. Specifically, despite an intense economic connection along the supply chain, there is a lack of evidence examining the effect of overall SCT on crash risk and the mechanism and heterogeneous effects related to supplier and customer information disclosure. Thus, we leverage the text analysis methodology to thoroughly investigate these matters.

Hypothesis development

Overall, we utilized the "bad news hiding" framework Chen (2001) proposed to investigate the influence mechanism, as shown in Fig. 1. Specifically, we posit that SCT influences a firm's bad news-holding behavior through earnings management and tax avoidance. In turn, these factors can affect crash risk. Throughout this process, heterogeneous supply chain information can generate varying effects, and information intermediaries' managerial incentives and informational production functions can play a moderating role.

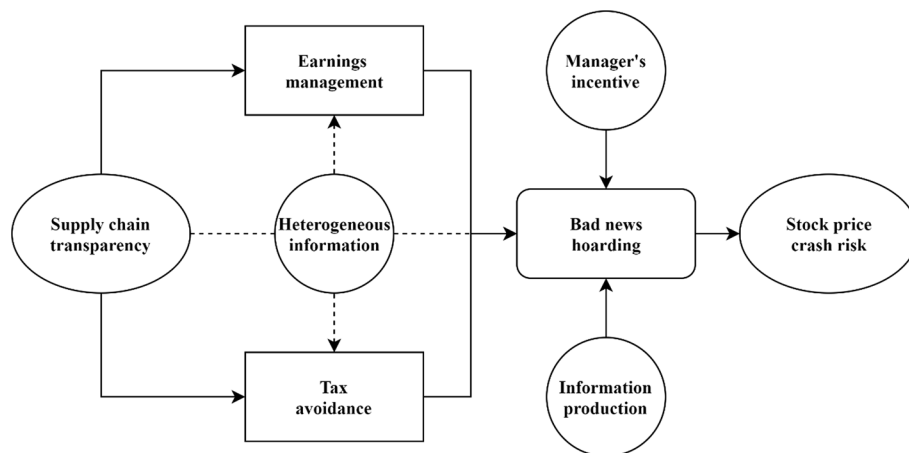


Fig. 1 Mechanism analysis

The impact of SCT on crash risk

The impact of a company’s disclosure of supply chain information is multifaceted. First, increased transparency may prevent management from concealing adverse news, mitigating the risk of stock price crashes. Second, it can amplify the proprietary costs of bad news concealment and selective reporting, consequently magnifying the risk of stock price crashes. Therefore, this study proposed two opposing hypotheses.

Hypothesis 1a Ceteris paribus, SCT significantly mitigates crash risk.

Hypothesis 1b Ceteris paribus, SCT significantly amplifies crash risk.

Supply chain transparency significantly mitigates crash risk. Supply chain transparency can serve as a tool for investor surveillance to prevent management from concealing negative news, thereby reducing crash risks. This allows investors to effectively assess supply chain intelligence, evaluate the quality of a firm’s financial information, and predict its future profitability. First, by analyzing the identity and transaction amounts of customers or suppliers, investors can assess the stability of a firm’s supply chain relationship, evaluate its reliance on major customers or suppliers, and determine the impact of changes in trading partners on its competitive position (Dhaliwal et al. 2016). Second, information about customers or suppliers gives investors insights into their governance, operations, and stock prices. Supplier identities are particularly crucial for investors to identify product quantity, quality, and costs, whereas customer identities help determine the authenticity of sales revenue, sustainability, and accounts receivable recoverability (Liu et al. 2024; Pandit et al. 2011). Third, analysts with access to firm information about their trading partners can offer investors more precise earnings forecasts, bridging the information gap between investors and management (Luo & Nagarajan 2015). In conclusion, an improvement in SCT can enhance the accessibility of information across different dimensions, including financial information, supply chain details, and intermediary-generated data. Such enhancements can serve as a mechanism to prevent management from

concealing negative news, thereby reducing the risk of stock price crashes. Furthermore, the voluntary disclosure of such information can assist companies in building trust with their supply chain partners, mitigating political risks, improving their reputations, and ultimately lowering the risk of cash flow fluctuations and stock price crashes (Amihud 2019; Wang et al. 2023; Wu & Jia 2018).

However, enhancing SCT may result in increased stock price crash risk. Proprietary costs are involved in information disclosure, which may impair a company's ability to protect sensitive information, such as supplier or customer confidentiality, and even suggest the source of its competitive advantage or cause supply chain vulnerabilities (Sodhi & Tang 2019). Competitors may exploit the acquired information to imitate the firm's products, lobby clients or suppliers, and deliberately disrupt the target firm's production and operational activities, increasing its cash flow and earnings fluctuations, thus amplifying crash risks. Furthermore, the disclosure of supply chain information may not be driven by the firm's intention to elevate transparency but by management's discretionary disclosure practices, which are associated with heightened crash risk. Specifically, because the disclosure of bad news concerning the supply chain may result in a decline in firm value and, thus, managers' compensation, managers may selectively reveal positive information while deliberately withholding negative information, leading to a cumulative build-up of crash risk (Khan et al., 2024; Macready et al. 2020).

The role of earnings management and tax avoidance

Earnings management and tax avoidance are two common practices employed by management to conceal bad news (Wan et al., 2023; Jo and Kim, 2007; Kim et al. 2011a). We posit that these may have vital implications for the risk governance effect of SCT. Therefore, we propose the following hypothesis:

Hypothesis 2 Ceteris paribus, earnings management, and tax avoidance mediate the negative relationship between SCT and crash risk.

Supply chain transparency can mitigate the likelihood of crashes by decreasing earnings management and tax avoidance activities. The disclosure of information related to supply chain management plays a pivotal role in rectifying information asymmetry and preventing managers from selectively manipulating earnings information. Jo and Kim (2007) find a favorable correlation between extensive disclosure and reduced levels of information asymmetry and earnings management. This ensures that negative news does not accumulate over time, preventing possible stock price crashes (Obaydin et al. 2021). Moreover, an open and transparent supply chain environment facilitates the detection of collusive tax planning activities among companies in both the upstream and downstream sectors. Cen et al. (2017) reveal that complex supply chain activities are related to incentivized tax practices, whereas Overesch and Wolff (2021) suggest that mandatory information disclosure can aid in reducing tax evasion. This identification enables investors to take corrective measures to prevent these practices from occurring in the future, thereby reducing the probability of crashes resulting from tax activities (Chen et al. 2022).

The effect of information production and manager's incentive

Drawing on the “bad news hiding” perspective, we propose that information producers’ and managers’ incentives to hide negative information play a crucial role in shaping the relationship between SCT and crash risks. Hence, we propose the following hypothesis:

Hypothesis 3 Ceteris paribus, the risk suppression effect is more pronounced among firms with a higher manager's incentive to conceal bad news and investors with better information acquisition abilities.

The impact of SCT on crash risk is influenced by the ability to produce information and manager incentives. While companies may only disclose partial supply chain information due to proprietary costs (Ellis et al. 2012), institutional investors and financial analysts can leverage their information-gathering advantages and production capabilities to disseminate relevant information to investors (Kim et al. 2019a, b). The more sophisticated institutional investors and financial analysts pay attention to a company's supply chain information, the more accurately it reflects the stock price and the less likely it is to hide and accumulate negative information (Zaman et al. 2021). However, agency theory suggests that management may prioritize short-term gains over long-term company value, potentially sacrificing the latter to boost current stock prices (Kim et al. 2011b). According to Baginski et al. (2018), managers may stop sharing bad news because of career-related anxieties surrounding their performance. However, disclosing supply chain information can deter such short-sighted behavior, leading to a stronger risk-suppression effect (She 2022).

Methods and data

Sample

Historically, researchers have concentrated primarily on developed countries. However, it is imperative to recognize that developing countries and emerging economies comprise most of the world's population and serve as key drivers of global economic growth and supply chains. China, the largest developing country and the second largest economy worldwide, assumes a pivotal role. Consequently, a comprehensive understanding of the role of SCT in China's financial risk management is important. To address the significant impact of the 2008 global financial crisis, this study employs data from Chinese A-share listed companies from 2009 to 2022. Supply chain information transparency is derived from annual report texts. In contrast, other financial and stock price data are obtained from the China Stock Market and Accounting Research (CSMAR) and Chinese Research Data Services (CNRDS) databases. Data processing adheres to established principles (Xu et al. 2014), including excluding B- and H-share listed enterprises,¹ special treatment or delisted enterprises, and those with severe sample deficiencies or from financial industries. In addition, samples with fewer than 30 weeks of cumulative stock trading days per year were excluded from the dataset. Ultimately, 20,870 observations

¹ As B-shares and H-shares are primarily intended for foreign investors and face a completely different investment environment compared to A-shares in China, we exclude these two categories of stocks.

were obtained. The continuous variables were winsorized at 1% and 99% percentiles to mitigate any influence from outliers.

Model design

To address the potential effect on estimation accuracy, we employ the following fixed-effects model to examine the influence of SCT on firms’ crash risk (Kim et al. 2014):

$$CrashRisk_{i,t+1} = \alpha_0 + \beta SCT_{i,t} + \gamma' Control_{i,t} + IndustryFE + YearFE + IndustryFE \times YearFE + \varepsilon_{i,t} \tag{1}$$

where i, t denote the firm and year, respectively. $CrashRisk_{i,t+1}$ represents the crash risk for firm i in period $t + 1$, proxied by the downside-upside volatility ratio ($DUVOL$) and the negative skewness coefficient of returns ($NCSKEW$), which will be further explained in Sect. "Dependent variable". $SCT_{i,t}$ denotes a firm’s level of SCT in a given year. In addition, we incorporate IndustryFE, YearFE, and Industry \times YearFE to control for industry fixed effects, year fixed effects, and industry-year interaction fixed effects. The vector $Control_{i,t}$ represents a set of control variables, while γ denotes the vector representing the corresponding regression coefficients. Of particular interest is the coefficient β , which measures the impact of SCT on crash risk and is, therefore, a vital focus of this study.

Variable definition and descriptive statistics

Dependent variable

In line with previous literature (Kim et al. 2011b, 2014), this study employs two commonly used variables as proxies for stock price crash risk. We estimate the market-adjusted rate of return for stock i using its weekly return data and Eq. (2).

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

where $R_{i,t}$ represents the return on stock i in week t and $R_{m,t}$ denotes the value-weighted A-share market return for that specific week. The weekly returns for firm i in week t are estimated using the equation $W_{i,t} = Ln(1 + \varepsilon_{i,t})$, where $\varepsilon_{i,t}$ signifies the residual mentioned in Eq. (2).

First, we use the negative coefficient of skewness crash risk, denoted as $NCSKEW$, as a proxy for crash risk. This is derived by negating the third moment of the firm-specific weekly returns in a given year and dividing it by the cubed standard deviation of these returns. More precisely, $NCSKEW$ for each firm i in year t is calculated as follows:

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

Second, we use the disparity in volatility between the upward and downward phases, known as down-to-up volatility ($DUVOL$), as a proxy for crash risk. To compute this, we first split the stock return sample for stock i into two subsets: the “up weeks” with weekly returns higher than the annual average and the “down weeks” with returns lower than it. We then separately calculate the standard deviations for the returns in each subset (specifically, R_d corresponds to the down weeks, and R_u corresponds to the up weeks). Finally, we employed the following model to derive the $DUVOL$ measure:

$$DUVOL_{i,t} = \ln[(n_u - 1) \sum_{\text{Down}} R_d^2 / (n_d - 1) \sum_{\text{Up}} R_u^2] \quad (4)$$

where n_u and n_d represent the number of weeks in which specific weekly returns $W_{i,t}$ for stock i exceed (fall below) the average annual return W_i .

Core independent variable

We constructed two proxies for SCT using textual data from annual corporate reports. Specifically, the number of disclosed supply chain partners with specific names (including suppliers and customers) is utilized as a measure of SCT (*SCT_Num*), along with their transaction proportion (*SCT_Ratio*). Discouring specific names (e.g., Huawei or Apple) of customers or suppliers in a company's annual report facilitates the acquisition of relevant publicly available or confidential information regarding the firm's supply chain. In contrast, the calculation excludes cases where no mention or disclosure of information lacks informative content (e.g., Supplier A, Customer 1). Overall, larger *SCT_Num* values signify elevated levels of transparency in the supply chain. Furthermore, *SCT_Ratio* denotes the proportion of transaction volume between the disclosed named partners compared to that of the five largest suppliers and customers combined. Higher values for *SCT_Ratio* indicate a higher degree of SCT.

Control variables

To enhance the reliability, we incorporated several controlling variables (Liu et al., 2023b; Kim et al. 2011a; Lou et al. 2024; Xu et al. 2014), including: stock annual returns (*Ret*), the standard deviation of weekly stock returns (*Sigma*), average excess turnover rate (*Dturn*), firm size (*Size*), return on assets (*ROA*), market-to-book ratio as a measure of growth potential (*MB*), leverage ratio (*Lev*) and information asymmetry measured by accruals-based earnings management (*DA*, the absolute value of discretionary accruals, as estimated using the performance-adjusted modified cross-sectional Jones (1991) model) developed by Cen et al. (2017). The definitions of the main variables are listed in Table 1.

Empirical results and analysis

Descriptive statistics

Table 2 presents the descriptive statistics of the main variables. Concerning corporate SCT, *SCT_Num* has an average value of 2.2884, implying that these firms generally disclose approximately two customer or supplier names in their supply chains. In contrast, the *SCT_Ratio*'s mean denotes that the disclosed transaction amount with the identified supply chain partners represents an average of 33.94% of the top five partner transaction amounts. Collectively, these results suggest inadequate and inconsistent levels of transparency in supply chains. Furthermore, the correlation analysis results in Panel C indicate a preliminary negative relationship between SCT and crash risk.

Results of benchmark regression

Table 3 presents the benchmark results for the impact of SCT on crash risk. We employ the volatility ratio *DUVOL* as the explained variable in columns (1) and (3)

Table 1 Variable definition

Variable	Definition
DUVOL	Ratio of up and down volatility in returns
NCSKEW	Coefficient of negative skewness in returns
SCT_Num	Number of disclosed specific supply chain partners
SCT_Ratio	Ratio of disclosed specific supply chain partner's transactions to total transactions with top five suppliers and customers
Ret	Annual stock return
Sigma	Standard deviation of weekly stock returns during the fiscal year
Dturn	Stock turnover rate
Size	Total asset (in logarithm)
ROA	Return on assets
MB	Market-to-book ratio
Lev	Asset-liability ratio
DA	Information asymmetry measured by abnormal accruals

Table 2 Descriptive statistics

Panel A: Summary statistics						
Variable	Observation	Mean	SD	Min	Median	Max
DUVOL	20,870	− 0.2105	0.4689	− 1.3894	− 0.2079	1.0756
NCSKEW	20,870	− 0.3201	0.7049	− 2.4412	− 0.2785	1.7509
SCT_Num	20,870	2.2884	3.6987	0.0000	0.0000	10.0000
SCT_Ratio	20,870	0.3394	0.5382	0.0000	0.0000	2.0000
Ret	20,870	0.0030	0.0094	− 0.0357	0.0017	0.0752
Sigma	20,870	0.0602	0.0221	0.0151	0.0562	0.2322
Dturn	20,870	− 0.0973	0.4795	− 6.8860	− 0.0333	4.3291
Size	20,870	22.3785	1.2684	19.5027	22.2273	26.0469
ROA	20,870	0.0489	0.0400	0.0009	0.0387	0.2078
MB	20,870	1.9021	1.1310	0.9024	1.5417	8.4663
Lev	20,870	0.4412	0.1977	0.0468	0.4391	0.8714
DA	20,870	0.0523	0.0513	0.0000	0.0372	0.4131

Panel B: Correlation analysis				
Variable	DUVOL	NCSKEW	SCT_Num	SCT_Ratio
DUVOL	1	0.883***	− 0.046***	− 0.040***
NCSKEW	0.879***	1	− 0.038***	− 0.033***
SCT_Num	− 0.048***	− 0.039***	1	0.974***
SCT_Ratio	− 0.034***	− 0.028***	0.894***	1

Pearson's correlation coefficients are presented in the lower-triangular cells, and Spearman's are in the upper triangle. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

and *NCSKEW* in the other columns. The OLS model incorporates industry, year, and industry–year fixed effects (FE) (i.e., Industry FE, Year FE, and IndustryYear FE) while utilizing robust standard errors clustered at the industry level. Our findings illustrate that the coefficients of *SCT_Num* and *SCT_Ratio* are significantly negative regardless of the dependent variables used. This finding indicates that SCT is negatively correlated with crash risk, implying that improving transparency within a supply chain can help reduce the likelihood of crashes. These results align with those of Pandit et al. (2011) and

Table 3 The results of benchmark regression

Variable	(1)	(2)	(3)	(4)
	DUVOL	NCSKEW	DUVOL	NCSKEW
SCT_Num	−0.0050*** (0.001)	−0.0058*** (0.001)		
SCT_Ratio			−0.0286*** (0.008)	−0.0326*** (0.011)
Ret	4.4153*** (0.569)	7.1931*** (0.919)	4.4248*** (0.568)	7.2040*** (0.922)
Sigma	−1.4700*** (0.169)	−1.9448*** (0.322)	−1.4883*** (0.173)	−1.9658*** (0.322)
Dturn	−0.0263** (0.010)	−0.0359** (0.013)	−0.0263** (0.010)	−0.0359** (0.013)
SIZE	−0.0141* (0.007)	−0.0055 (0.009)	−0.0136* (0.007)	−0.0049 (0.009)
ROA	0.4786*** (0.138)	0.9726*** (0.197)	0.4806*** (0.138)	0.9750*** (0.198)
MB	0.0200*** (0.005)	0.0335*** (0.010)	0.0202*** (0.005)	0.0337*** (0.011)
LEV	0.0891*** (0.029)	0.1136** (0.041)	0.0887*** (0.029)	0.1131** (0.041)
DA	0.0787 (0.054)	0.1375 (0.082)	0.0785 (0.054)	0.1373 (0.081)
Constant	0.0873 (0.161)	−0.2611 (0.198)	0.0751 (0.159)	−0.2753 (0.196)
Year FE	Y	Y	Y	Y
Industry FE	Y	Y	Y	Y
Industry × Year FE	Y	Y	Y	Y
N	20,870	20,870	20,870	20,870
Adj. R ²	0.0533	0.0500	0.0529	0.0497

Standard errors (in parentheses) are clustered at the industry level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

support H1a, revealing that the benefits of SCT in reducing crash risk are greater than the associated costs, highlighting the importance of such transparency for firms to manage their financial risks effectively.

Robustness tests

This section examines the robustness of SCT's impact of SCT using a series of approaches.

Reverse causality issue

Supply chain information disclosure is an endogenous firm characteristic that can affect the risk of stock price crashes. While our previous analysis controlled for this effect using crash risk as a dependent variable, this section employs a difference-in-differences model and a 2SLS regression to address this concern.

Difference-in-difference (DiD) model To address the potential issue of reverse causality, we use an exogenous shock to corporate supply chain disclosures, specifically, the revision of disclosure requirements for the annual reports of listed companies by the China

Table 4 Results of difference-in-difference

Variable	(1) NCSKEW	(2) NCSKEW	(3) DUVOL	(4) DUVOL
Treat × Post	−0.0638*** (0.020)	−0.0530** (0.020)	−0.0421*** (0.013)	−0.0339** (0.013)
Constant	−0.2838*** (0.011)	−0.4720** (0.184)	−0.1828*** (0.008)	−0.1137 (0.142)
Control	N	Y	N	Y
Year FE	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y
Industry × Year FE	Y	Y	Y	Y
N	20,870	20,870	20,870	20,870
Adj. R ²	0.0046	0.0197	0.0053	0.0184

Standard errors (in parentheses) are clustered at the industry level. The asterisks (***) denote statistical significance at 1%, (**) at 5%, and (*) at 10% levels

Securities Regulatory Commission (CSRC) in 2012. This policy document explicitly encourages companies to disclose detailed information on their top five suppliers and customers, including their names and procurement amounts. Although this policy was not mandatory, many companies strengthened their supply chain information disclosure after its implementation. We construct a treatment group dummy variable *Treat* (taking 1 for companies that did not disclose their supply chain partner information before 2012 but disclosed it afterward, and 0 otherwise), a post-2012 dummy variable *Post* (taking 1 for years from 2012 onwards, and 0 otherwise), and an interaction term between them—*Treat × Post*—to construct a DiD model with a two-way fixed effects form. We report the results in Table 4, where columns (1) and (3) do not control for any other variables, and the other columns control for the same characteristics as in Eq. (1). Our findings indicate that the coefficient of the interaction term *Treat × Post* was significantly negative. This finding suggests that the shock of supply chain disclosures effectively mitigates the likelihood of crashes, reinforcing the robustness of our results.

Two-stage least squares (2SLS) regression To mitigate the potential endogeneity issue arising from the relationship between SCT and stock price crash risk, we employ a two-stage least squares (2SLS) approach and present the results in Table 5. Specifically, we used the response rate of companies on online interactive platforms obtained from the CNRDS database as an instrumental variable for SCT. Unlike traditional media, online platforms offer greater convenience to small shareholders and facilitate their engagement in company decision-making and inquiries. We believe that companies that proactively respond to small investors online are more inclined to voluntarily disclose supply chain-related information. The first-stage test results reveal that the Wald F statistic is significantly greater than the empirical value of 10, indicating the appropriateness of selecting this instrumental variable. Moreover, the results from the second-stage estimation indicate significantly negative coefficients of the instrumental variable, which further strengthens support for our research hypothesis.

Table 5 Results of two-stage least squares

Variable	(1) NCSKEW	(2) DUVOL	(3) NCSKEW	(4) DUVOL
SCT_Num	-0.0685*** (0.019)	-0.0678*** (0.014)		
SCT_Ratio			-0.9411*** (0.298)	-0.9320*** (0.230)
Wald F statistic	117.725	117.725	33.555	33.555
Control	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
Industry FE	Y	Y	Y	Y
Industry × Year FE	Y	Y	Y	Y
N	17,618	17,618	17,618	17,618

Standard errors (in parentheses) are clustered at the industry level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Because of the negative R-squared values in the regression results, they are not reported. According to the *Stata Journal*, a negative R-squared may occur in 2SLS models but does not affect model evaluation

Table 6 Results of propensity score matching method

Variable	(1) DUVOL	(2) NCSKEW	(3) DUVOL	(4) NCSKEW
SCT_Num	-0.0050*** (0.001)	-0.0058*** (0.001)		
SCT_Ratio			-0.0286*** (0.008)	-0.0327*** (0.011)
Constant	0.0770 (0.055)	0.1340 (0.083)	0.0768 (0.055)	0.1338 (0.083)
Control	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
Industry FE	Y	Y	Y	Y
Industry × Year FE	Y	Y	Y	Y
N	14,568	14,568	14,568	14,568
Adj. R ²	0.0550	0.0563	0.0546	0.0561

Standard errors (in parentheses) are clustered at the industry level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Selection bias

Propensity Score Matching (PSM) method Given that samples with higher and lower levels of SCT may have inherent differences, this study matches the samples based on their SCT indicators using PSM to ensure comparability. A treatment group comprising firms with SCT levels above the median is constructed, and a matched sample from other firms is selected using the optimal nearest neighbor matching method to construct a control group with the control variables in Eq. (1) as covariates. We conducted a re-estimation, and the results in Table 6 demonstrate that the regression coefficients of *SCT_Num* and *SCT_Ratio* are both significantly negative, confirming an adverse correlation between SCT and crash risk. Overall, our findings address the inherent differences between samples with varying levels of SCT.

Heckman’s two-step method Our study acknowledges the potential for selection bias as a firm’s specific demands may influence the supply chain disclosure strategy (Luo

Table 7 Results of Heckman’s two-step method

Variable	First stage	Second stage		First stage	Second stage	
	(1)SCT_Dum	(2)DUVOL	(3)NCSKEW	(4)SCT_Dum	(5)DUVOL	(6)NCSKEW
SCT_Num_Ind	1.3025*** (0.195)					
SCT_Ratio_Ind				1.3025*** (0.195)		
SCT_Num		−0.0058*** (0.001)	−0.0068*** (0.001)			
SCT_Ratio					−0.0374*** (0.010)	−0.0430*** (0.012)
IMR_SCT_Num		0.0205 (0.018)	0.0670** (0.028)			
IMR_SCT_Ratio					0.0070 (0.015)	0.0489* (0.024)
Constant	2.3740*** (0.593)	−0.0622 (0.184)	−0.4538* (0.231)	2.3740*** (0.593)	−0.0451 (0.183)	−0.3746 (0.228)
Insig2u	0.6430*** (0.053)			0.7901*** (0.056)		
Control	Y	Y	Y	Y	Y	Y
Industry FE	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
Industry × Year FE	Y	Y	Y	Y	Y	Y
N	17,612	17,612	17,612	17,612	17,612	17,612
Adj. R ²		0.0567	0.0558		0.0562	0.0555

The inverse Mills ratio (*IMR_SCT_Num* and *IMR_SCT_Ratio*) coefficients are not equal to zero and are mostly statistically significant, suggesting the existence of selection bias in our sample and the validity of our analysis. The standard errors (in parentheses) were clustered at the industry level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

& Nagarajan 2015). To address this issue, Heckman’s two-step method is employed. In the first stage, a selection model is constructed to deal with sample selection problems, with the dependent variable being *SCT_Dum* (a dummy for whether the firm discloses the names of its supply chain partners). We introduce an exogenous instrumental variable, *SCT_Num_Ind* (*SCT_Ratio_Ind*), which represents the industry average level of SCT (excluding the given firm). The other variables are as in Eq. (1). Table 7 presents the results of Heckman’s two-stage regression model. *SCT_Num* and *SCT_Ratio* have significant negative coefficients that are consistent with the benchmark results. This indicates that even after mitigating the potential issues of self-selection, the risk-management effect of SCT still holds.

Additional robustness checks

This study conducted robustness checks using various measures. First, alternative proxy variables, *SCT_to_ALL_Ratio* (the ratio of disclosed supply chain partners’ names to the total transaction amount) and *SCT_Dum* (a dummy variable for whether supply chain partner names are disclosed), are used to replace the transparency proxies (Gong et al. 2022), which may be affected by measurement bias. Second, we incorporate the proxies for crash risk in year t ($DUVOL_t$ and $NCSKEW_t$) because firms exhibiting high crash

risk in year t are characterized by a lower likelihood of experiencing a collapse in year $t+1$ (Barany et al. 2012; Xu et al. 2021). Moreover, we introduce firm-fixed effects into our framework to account for potential individual-dependent effects. Third, the Chinese stock market experienced a significant and extensive downturn in 2015, with numerous individual stocks experiencing significant price declines. We excluded samples from that year to ensure robustness in mitigating the interference caused by this event. Fourth, COVID-19-related lockdown policies, implemented in China in 2020 and continued until the end of 2022, profoundly impacted the country's supply chain. To address the country-level shocks caused by the COVID-19 pandemic, we excluded samples from 2020 and beyond. The results of these tests in Table 8 support Hypothesis 1a and confirm the robustness of the estimates in Table 3. Overall, these measures provide additional support for our findings.

Further analysis

Despite evidence that SCT is negatively related to crash risk, the underlying mechanisms remain unclear. This section examines this channel from earnings management and tax avoidance perspectives. Furthermore, we explore how managerial incentives and information production mechanisms affect risk-mitigating effects and other alternative explanations. Finally, we investigate heterogeneity in the effects of different types of supply chain information.

The role of earnings management and tax avoidance

Numerous studies suggest that crash risk negatively correlates with earnings management behavior (Jo & Kim 2007). Specifically, when SCT is low, the management possesses a significant information advantage, enabling it to manipulate information disclosure through earnings management and other strategies. This allows the management to selectively report positive news while concealing negative information, resulting in concentration and increased crash risk. However, introducing comprehensive supply chain information enables investors to accurately assess a company's operating conditions. Consequently, increased SCT effectively increases the difficulties and pressures associated with concealing unfavorable news through earnings management, thereby decreasing the risk of a significant decline in stock prices (Obaydin et al. 2021).

Agency theory suggests that tax avoidance activities may increase opportunistic behaviors through management. The supply chain is highly complex, and stakeholders find obtaining accurate and reliable information challenging. An opaque information environment in the supply chain creates opportunities for companies to evade taxes (Cen et al. 2017). Specifically, managerial collusion with upstream or downstream entities for tax planning is more likely in instances characterized by inadequate information environments within the supply chain. Consequently, this increases the likelihood of being subjected to penalties from tax authorities, securities regulators, and capital markets upon discovery. Such actions infringe upon investor interests and exacerbate the risk of financial downturns (Lee and Lee, 2024; Kim et al. 2011a). Therefore, companies can reduce the likelihood of aggressive tax practices and mitigate crash risks by promoting SCT.

Table 8 Results of additional robustness checks

Panel A: Alternative proxy variables				
Variable	(1)	(2)	(3)	(4)
	DUVOL	NCSKEW	DUVOL	NCSKEW
SCT_to_ALL_Ratio	-0.1273*** (0.022)	-0.1414*** (0.026)		
SCT_Dum			-0.0437*** (0.009)	-0.0522*** (0.013)
Constant	-0.0341 (0.175)	-0.3637 (0.220)	-0.0430 (0.183)	-0.3703 (0.234)
Control	Y	Y	Y	Y
Industry FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
Industry × Year FE	Y	Y	Y	Y
N	17,612	17,612	17,612	17,612
Adj. R ²	0.0569	0.0555	0.0564	0.0554
Panel B: Additional control variable				
Variable	(1)	(2)	(3)	(4)
	DUVOL _{t+1}	DUVOL _{t+1}	NCSKEW _{t+1}	NCSKEW _{t+1}
DUVOL _t	-0.0623*** (0.011)	-0.0624*** (0.011)		
NCSKEW _t			-0.0564*** (0.013)	-0.0565*** (0.013)
SCT_Num	-0.0030** (0.001)		-0.0031* (0.002)	
SCT_Ratio		-0.0237** (0.010)		-0.0249** (0.012)
Constant	-1.4246*** (0.276)	-1.4156*** (0.273)	-2.8580*** (0.435)	-2.8485*** (0.433)
Control	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
Industry × Year FE	Y	Y	Y	Y
N	18,866	18,866	18,866	18,866
Adj. R ²	0.1425	0.1426	0.1406	0.1406
Panel C: The shock of the Chinese 2015 stock market crisis				
Variable	(1)	(2)	(3)	(4)
	DUVOL	NCSKEW	DUVOL	NCSKEW
SCT_Num	-0.0054*** (0.001)	-0.0062*** (0.001)		
SCT_Ratio			-0.0299*** (0.008)	-0.0341*** (0.011)
Constant	0.0504 (0.164)	-0.3050 (0.204)	0.0371 (0.163)	-0.3204 (0.202)
Control	Y	Y	Y	Y
Industry FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
Industry × Year FE	Y	Y	Y	Y
N	19,745	19,745	19,745	19,745
Adj. R ²	0.0481	0.0461	0.0476	0.0458

Table 8 (continued)

Panel D: The shock of COVID-19

Variable	(1)	(2)	(3)	(4)
	DUVOL	NCSKEW	DUVOL	NCSKEW
SCT_Num	-0.0064*** (0.001)	-0.0078*** (0.001)		
SCT_Ratio			-0.0453*** (0.008)	-0.0543*** (0.011)
Constant	-0.1337 (0.196)	-0.4491* (0.232)	-0.1439 (0.196)	-0.4621* (0.232)
Control	Y	Y	Y	Y
Industry FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
Industry × Year FE	Y	Y	Y	Y
N	16,140	16,140	16,140	16,140
Adj. R ²	0.0587	0.0576	0.0583	0.0573

Standard errors (in parentheses) are clustered at the industry level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Supply chain transparency is crucial in mitigating financial risk through two distinct channels: curtailing corporate earnings management practices and minimizing tax avoidance. To examine the effects of these mechanisms, we use the following econometric model:

$$CrashRisk_{i,t+1} = \alpha_0 + \beta_2 SCT_{i,t} \times M_{i,t} + \beta_3 SCT_{i,t} + \beta_4 M_{i,t} + \gamma' Control_{i,t} + IndustryFE + YearFE + IndustryFE \times YearFE + \varepsilon_{i,t} \tag{5}$$

where $M_{i,t}$ represents two mechanisms, earnings management (DA) and tax avoidance (ETR), the remaining parameters had the same measurements as those in Eq. (1). If the coefficient of $SCT_{i,t} \times M_{i,t}$ is significant, it indicates that SCT affects crash risk through this pathway (i.e., earnings management or tax avoidance).

We employ abnormal accruals (DA ; a larger DA implies a higher level of earnings management activities undertaken by the firm) as a measure of earnings management (Cen et al. 2017). Moreover, we use Eq. (5) to conduct a path analysis of earnings management and present our findings in Table 9. Our findings indicate that regardless of the explanatory variable SCT_Num or SCT_Ratio , their interactions with earnings management DA are significantly negative. These results suggest that SCT can effectively deter corporate earnings management practices, thereby mitigating the likelihood of crashes.

We analyze the impact of tax avoidance by conducting a path analysis and introducing ETR , which refers to the difference between nominal and actual tax rates (a higher ETR signifies a greater degree of tax avoidance by the firm) and its interaction with SCT. Our findings in Panel B of Table 9 suggest that the coefficients of $SCT_Num \times ETR$ and $SCT_Ratio \times ETR$ are significantly negative at the 1% level. This implies that improving SCT can help restrain management’s tax avoidance behavior, reducing crash risk. These results were consistent with those reported by J.-B. Kim et al. (2011a) provide valuable insights into the significance of corporate tax management concerning the management risk effect of SCT.

Table 9 Results of path analysis

Panel A: Path Analysis of Earnings Management				
Variable	(1)	(2)	(3)	(4)
	DUVOL	NCSKEW	DUVOL	NCSKEW
SCT_Num	− 0.0027 (0.002)	− 0.0021 (0.002)		
SCT_Num × DA	− 0.0048** (0.002)	− 0.0076** (0.003)		
SCT_Ratio			− 0.0126 (0.012)	− 0.0067 (0.015)
SCT_Ratio × DA			− 0.0327* (0.016)	− 0.0531** (0.022)
Constant	0.0895 (0.160)	− 0.2577 (0.197)	0.0771 (0.158)	− 0.2721 (0.194)
Control	Y	Y	Y	Y
Industry FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
Industry × Year FE	Y	Y	Y	Y
N	20,870	20,870	20,870	20,870
Adj. R ²	0.0537	0.0504	0.0533	0.0501
Panel B: Path analysis of tax avoidance				
Variable	(1)	(2)	(3)	(4)
	DUVOL	NCSKEW	DUVOL	NCSKEW
ETR	0.0299 (0.020)	0.0579** (0.024)	0.0331* (0.018)	0.0570*** (0.020)
SCT_Num	− 0.0036*** (0.001)	− 0.0039** (0.001)		
SCT_Num × ETR	− 0.0037*** (0.001)	− 0.0044*** (0.001)		
SCT_Ratio			− 0.0160 (0.011)	− 0.0200 (0.014)
SCT_Ratio × ETR			− 0.0305*** (0.010)	− 0.0280* (0.014)
Constant	0.0775 (0.173)	− 0.2306 (0.225)	0.0636 (0.172)	− 0.2469 (0.223)
Control	Y	Y	Y	Y
Industry FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
Industry × Year FE	Y	Y	Y	Y
N	20,870	20,870	20,870	20,870
Adj. R ²	0.0556	0.0538	0.0551	0.0534

Standard errors (in parentheses) are clustered at the industry level

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 10 The effect of information production

Panel A: Institutional investors				
Variable	(1)	(2)	(3)	(4)
	Low Inst	High Inst	(3) Low Inst	(4) High Inst
SCT_Num	-0.0033* (0.002)	-0.0083*** (0.002)		
SCT_Ratio			-0.0001 (0.018)	-0.0468*** (0.017)
Constant	0.0943 (0.182)	-0.4509 (0.353)	-0.0018 (0.256)	-0.6448** (0.304)
Control	Y	Y	Y	Y
Industry FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
Industry × Year FE	Y	Y	Y	Y
Chow test	2.50***		3.05***	
N	10,420	10,431	8965	10,242
Adj. R ²	0.0393	0.0646	0.0400	0.0563
Panel B Analyst coverage				
Variable	(5)	(6)	(7)	(8)
	Low Cover	High Cover	Low Cover	High Cover
SCT_Num	0.0003 (0.003)	-0.0064** (0.003)		
SCT_Ratio			-0.0051 (0.018)	-0.0536** (0.021)
Constant	-1.4454* (0.811)	-0.4899* (0.265)	0.2384 (0.312)	-0.4959* (0.267)
Control	Y	Y	Y	Y
Industry FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
Industry × Year FE	Y	Y	Y	Y
Chow test	4.09***		4.28***	
N	7783	7463	7783	7463
Adj. R ²	0.0411	0.0653	0.0411	0.0653

Standard errors (in parentheses) are clustered at the industry level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The findings on *DUVOL* as the dependent variable are presented in Table 14 of the Appendix

The effect of information production

The preliminary analysis reveals that firms with greater SCT face a lower risk of stock price crashes. The research framework of this study is grounded in the hypothesis of “bad news hiding,” but the precise mechanisms by which these negative signals are revealed remain unclear. Therefore, we examine the roles of two information producers, institutional investors, and analysts, in producing and processing these messages.

First, institutional investors possess remarkable information-mining capabilities, making them crucial information producers in the capital market (Lee et al. 2023b). To explore the effect of institutional investors, we categorized the sample into two groups based on institutional ownership and conducted separate regression analyses using Eq. (1). Our findings, as presented in Panel A of Table 10, reveal that the coefficients of *SCT_Num* and *SCT_Ratio* are negative in the high institutional ownership groups (significant at the 10% level) and are greater than those in the low institutional ownership group. This may be attributed to professional institutional investors' interpretative proficiency with information compared to small retail investors (Blau et al. 2015). Moreover, higher levels of institutional shareholding led to greater corporate governance and information efficiency. Thus, institutional investors can accurately interpret disclosed supply chain information and promptly integrate it into stock prices through relevant operations.

Second, we examined the role of analysts as information producers in this process. Our sample is divided into two subgroups based on analyst coverage: high and low analyst coverage, with the latter defined as less than the median. Using Eq. (1), we conducted separate regressions for each subgroup. Our findings, as shown in Panel B of Table 10, reveal that the coefficients of *SCT* are insignificant for low analyst attention groups. However, the high analyst coverage groups' *SCT* coefficients are significantly negative. This may be attributed to the fact that supply chain partner names and transaction amount disclosure only provide fragmented information about a company's operations, making it difficult for investors to accurately evaluate companies based on this limited information. Conversely, analysts can integrate and analyze disclosed supply chain information and information from suppliers, customers, official announcements, and other sources. By doing so, they can provide valuable insights for investors that can be communicated through analyst reports or other channels. This facilitates the timely absorption of information by the market and its reflection in stock prices, ultimately reducing the risk of a stock crash.

The effect of a manager's incentive

As previously examined, divulging details about the supply chain can aid investors in detecting management's attempts to withhold bad news. However, this effect may be more pronounced in firms with stronger incentives to retain such information. We developed proxy variables for management incentives based on managers' shareholding ratios and state ownership to investigate this hypothesis. Specifically, managers' shareholding ratio provides insights into the economic motivation of managers who hold shares, as changes in stock prices can impact their income. Meanwhile, managers of state-owned enterprises in China may have political incentives to suppress negative information to prevent market crashes during their tenure (Xu et al. 2014).

We divide our sample based on whether the managerial shareholding ratio exceeds the median value (low- and high-equity groups) and whether the enterprise is state-owned (SOE and non-SOEs). Using Eq. (1), we estimate each group separately to identify any differential effects on supply chain information disclosure associated with managers' incentives. Table 11 provides the results with *NCSKEW* as the explained variable. It

Table 11 The effect of a manager’s incentive

Panel A: Manager’s economic incentive				
Variable	(1)	(2)	(3)	(4)
	Low equity	High equity	Low equity	High equity
SCT_Num	− 0.0029 (0.004)	− 0.0066*** (0.001)		
SCT_Ratio			− 0.0109 (0.035)	− 0.0386*** (0.010)
Constant	− 0.4720* (0.269)	− 0.1982 (0.194)	− 0.4874* (0.275)	− 0.2141 (0.191)
Control	Y	Y	Y	Y
Industry FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
Industry × Year FE	Y	Y	Y	Y
Chow test	1.84**		1.88**	
N	5085	15,758	5085	15,758
Adj. R ²	0.0615	0.0588	0.0612	0.0588
Panel B: Manager’s political incentive				
Variable	(1)	(2)	(3)	(4)
	Non-SOE	SOE	Non-SOE	SOE
SCT_Num	− 0.0002 (0.003)	− 0.0118*** (0.002)		
SCT_Ratio			0.0061 (0.021)	− 0.0663*** (0.011)
Constant	− 0.4225 (0.345)	− 0.1277 (0.176)	− 0.4311 (0.349)	− 0.1576 (0.169)
Control	Y	Y	Y	Y
Industry FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
Industry × Year FE	Y	Y	Y	Y
Chow test	5.50***		5.29***	
N	10,935	8255	10,935	8255
Adj. R ²	0.0469	0.0706	0.0469	0.0693

Standard errors (in parentheses) are clustered at the industry level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The findings on *DUVOL* as the dependent variable are presented in Table 15 of the Appendix

shows significant and negative coefficients for SCT in the high-equity and SOE groups, which are greater than other sub-samples. These findings support our hypothesis that increased SCT mitigates crash risk in firms with greater management wealth and political incentives.

Other alternative explanations

One explanation is that higher-level relationship-specific investments increase the proprietary costs of disclosing information about customers and suppliers, thereby increasing the risk of competitive advantage leakage. This scenario may lead to significant

Table 12 Other alternative explanations

Panel A: Relationship-specific investments				
Variable	(1)	(2)	(3)	(4)
	Low R&D	High R&D	Low R&D	High R&D
SCT_Num	-0.0069** (0.003)	-0.0014 (0.002)		
SCT_Ratio			-0.0256 (0.020)	-0.0273** (0.012)
Constant	-0.0469 (0.159)	0.1580 (0.285)	-0.0722 (0.156)	0.1659 (0.282)
Control	Y	Y	Y	Y
Industry FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
Industry × Year FE	Y	Y	Y	Y
Chow test	2.80***		2.29**	
N	9024	6426	9024	6426
Adj. R ²	0.0517	0.0385	0.0507	0.0388
Panel B: Switching costs				
Variable	(5)	(6)	(7)	(8)
	Low PCM	High PCM	Low PCM	High PCM
SCT_Num	-0.0078*** (0.002)	-0.0026* (0.001)		
SCT_Ratio			-0.0416*** (0.014)	-0.0153* (0.009)
Constant	-0.3125 (0.200)	-0.3868 (0.258)	-0.3297 (0.197)	-0.3942 (0.259)
Control	Y	Y	Y	Y
Industry FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
Industry × Year FE	Y	Y	Y	Y
Chow test	2.28**		2.22**	
N	10,701	8485	10,701	8485
Adj. R ²	0.0473	0.0589	0.0467	0.0588

Standard errors (in parentheses) are clustered at the industry level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The findings on *DUVOL* as the dependent variable are presented in Table 16 in the Appendix

fluctuations in a firm’s cash flow and profits, amplifying crash risk. We used research and development intensity (R&D) as a proxy variable for relationship-specific investments to investigate this concern. We partitioned our sample into two cohorts based on R&D intensity for the sub-sample analysis. As presented in Table 12, the coefficients of SCT are significantly negative in the low-R&D subgroup but not significant in the other subgroups. This finding aligns with that of Ma et al. (2020) and indicates that relationship-specific investment weakens the risk-reducing effect of SCT. However, combining Table 3 and 12, our findings reveal that, while relationship-specific investments have played a certain role, the main impact remains in suppressing crash risk by increasing SCT. This supports hypothesis H1a with greater conviction.

Switching costs are another risk factor related to SCT. An abrupt shift in a company’s supplier or customer may trigger cost or income shocks, leading to significant investor reactions and sharp declines in stock prices. This bad news can be concealed by a company when supply chain information is not disclosed. To address this concern, we use the Lerner index (*PCM*), which reflects a firm’s market power (higher values indicate lower switching costs), as a proxy variable for switching costs. This is because trading partners with low switching costs are highly unlikely to collude with customers or suppliers to hide negative information from investors (S. Li & Zhan 2019). We partition the sample into two subsets according to whether it is greater than the average *PCM* and estimate them separately. These results in Table 12 align with our hypothesis and are only significant for the low-switching-cost subsamples. This finding suggests that although switching costs are a potential mechanism through which SCT affects collapse risk, it is not the primary factor.

Heterogeneous effect of different types of supply chain information

The disclosure of information by customers and suppliers in supply chain activities has varying effects on stock price crash risk, given their distinct roles in revenue and cost. Hence, we refine SCT into two categories—supplier information transparency (*SCT_Num_SU*, *SCT_Ratio_SU*) and customer information transparency (*SCT_Num_CU*, *SCT_Ratio_CU*)—to investigate their differentiated effects on crash risk. Table 13 reports the results of the heterogeneous effects of different types of supply chain information with *NCSKEW* as the explained variable.

Table 13 Heterogeneous effect of different types of supply chain information

	(1)	(2)	(3)	(4)	(5)	(6)
SCT_Num_SU	−0.0132*** (0.003)		−0.0152** (0.006)			
SCT_Num_CU		−0.0067* (0.003)	0.0027 (0.006)			
SCT_Ratio_SU				−0.0716*** (0.020)		−0.0709*** (0.020)
SCT_Ratio_CU					−0.0258 (0.017)	−0.0015 (0.017)
Constant	−0.2530 (0.189)	−0.2798 (0.202)	−0.2548 (0.191)	−0.2693 (0.189)	−0.2928 (0.196)	−0.2691 (0.191)
Control	Y	Y	Y	Y	Y	Y
Industry FE	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
Industry × Year FE	Y	Y	Y	Y	Y	Y
N	20,870	20,870	20,870	20,870	20,870	20,870
Adj. R ²	0.0503	0.0495	0.0503	0.0500	0.0493	0.0499

Standard errors (in parentheses) are clustered at the industry level. *** p < 0.01, ** p < 0.05, * p < 0.1. The findings on *DUVOL* as the dependent variable are presented in Table 17 of the Appendix

Our findings demonstrate that supplier and customer information transparency significantly negatively impacts crash risk, further supporting hypothesis H1a. However, the estimated coefficients of supplier transparency are significantly larger than customer transparency. Moreover, when we incorporated both sides into the model, we found that the coefficient estimate of customer transparency lost its significance. Thus, our results suggest supplier transparency has a more pronounced effect on curbing crash risk than customer transparency. This phenomenon can be explained by investors' current focus on earnings, which aligns with customer interests. Consequently, companies can use cost-control measures that reflect their supplier relationships to withhold bad news.

Conclusions and implications

The intricate network of economic connections among firms has witnessed a surge, with the supplier-customer relationship acting as a catalyst for transformative shifts. This study examines the pivotal role of SCT in shaping the risk of stock price crashes, utilizing an extensive dataset compiled from Chinese nonfinancial listed firms spanning 2009–2022. To measure the extent of SCT, our analysis centers on meticulously examining the names and transaction proportions of supply chain partners, as disclosed in firms' annual reports. Our empirical findings underscore that bolstering SCT can substantially reduce crash risk, primarily by curbing tax avoidance and earnings management. Notably, our analysis reveals the noteworthy beneficial impact of SCT in firms where the management exhibits a stronger inclination to conceal unfavorable news, particularly when coupled with investors who possess enhanced abilities to acquire information. Furthermore, our results shed light on the varying degrees of influence exerted by supplier and customer information transparency, with the former assuming a more critical role in mitigating crash risk than the latter. This study makes a significant contribution to the ongoing discourse surrounding the question of whether government authorities should mandate increased supply chain disclosure. These findings are important in facilitating a deeper understanding of the potential advantages of fostering greater transparency within supply chains. Moreover, this study provides new empirical evidence substantiating the positive influence of SCT in effectively managing crash risks.

The practical implications of this study are significant for policymakers, managers, and investors. Policymakers should consider promoting measures to incentivize firms to enhance their SCT. This could involve mandating firms to disclose information regarding their customers and suppliers and offering incentives to firms that voluntarily disclose such information. Furthermore, we explore the drivers of crash risk through the lens of SCT and highlight the crucial role of policymakers in implementing regulations that curb tax avoidance and earnings management practices while promoting greater transparency in financial reporting. Firms seeking to manage their financial risk should prioritize minimizing opportunistic behavior and enhancing voluntary disclosure of information about supply chain partners, particularly information related to suppliers. In addition, ambitious enterprises should focus on effectively utilizing information intermediaries and enhancing managerial incentive systems, both political and economic. However, investors should emphasize SCT more, strive to acquire a wider range of

supply chain information, and enhance their ability to analyze and utilize it effectively in making investment decisions. However, this study is still limited. (1) Given supply chain relationships' intricate and complex nature, future research can explore more encompassing measurement methods. (2) Because of imperfect supply chain information disclosure systems, our findings might only capture a fraction of them, and future studies should consider exploring the effects of SCT from alternative angles.

Appendix

See Table 14, 15, 16 and 17.

Table 14 The effect of information production (with DUVOL as dependent variable)

Panel A: Institutional investors				
Variable	(1)	(2)	(3)	(4)
	Low Inst	High Inst	(3) Low Inst	(4) High Inst
SCT_Num	-0.0032*** (0.001)	-0.0066*** (0.002)		
SCT_Ratio			-0.0109 (0.012)	-0.0376*** (0.012)
Constant	0.4100*** (0.100)	-0.0532 (0.273)	0.3053* (0.180)	-0.1903 (0.200)
Control	Y	Y	Y	Y
Industry FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
Industry × Year FE	Y	Y	Y	Y
Chow test	2.39***		3.06***	
N	10,420	10,431	8965	10,242
Adj. R ²	0.0472	0.0634	0.0456	0.0560
Panel B: Analyst coverage				
Variable	(5)	(6)	(7)	(8)
	Low Cover	High Cover	Low Cover	High Cover
SCT_Num	-0.0019 (0.002)	-0.0041** (0.002)		
SCT_Ratio			-0.0143 (0.011)	-0.0363** (0.015)
Constant	-0.2361 (0.525)	-0.1840 (0.203)	0.4602** (0.205)	-0.1857 (0.205)
Control	Y	Y	Y	Y
Industry FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
Industry × Year FE	Y	Y	Y	Y
Chow test	2.24**		2.37***	
N	7435	7463	7783	7463
Adj. R ²	0.1548	0.0636	0.0502	0.0638

The standard errors (in parentheses) are clustered at the industry level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 15 The effect of manager's incentive (with DUVOL as dependent variable)

Panel A: Manager's economic incentive				
Variable	(1)	(2)	(3)	(4)
	Low equity	High equity	Low equity	High equity
SCT_Num	− 0.0032 (0.003)	− 0.0056*** (0.001)		
SCT_Ratio			− 0.0170 (0.024)	− 0.0325*** (0.008)
Constant	− 0.1658 (0.183)	0.1634 (0.173)	− 0.1736 (0.185)	0.1495 (0.171)
Control	Y	Y	Y	Y
Industry FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
Industry × Year FE	Y	Y	Y	Y
Chow test	1.44		1.41	
N	5085	15,758	5085	15,758
Adj. R ²	0.0418	0.0562	0.0415	0.0557
Panel B: Manager's political incentive				
Variable	(1)	(2)	(3)	(4)
	Non-SOE	SOE	Non-SOE	SOE
SCT_Num	− 0.0020 (0.002)	− 0.0091*** (0.001)		
SCT_Ratio			− 0.0099 (0.015)	− 0.0512*** (0.008)
Constant	− 0.0256 (0.245)	0.1718 (0.169)	− 0.0314 (0.248)	0.1495 (0.164)
Control	Y	Y	Y	Y
Industry FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
Industry × Year FE	Y	Y	Y	Y
Chow test	4.02***		3.68***	
N	10,935	8255	10,935	8255
Adj. R ²	0.0492	0.0717	0.0491	0.0701

The standard errors (in parentheses) are clustered at the industry level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 16 Other alternative explanations (with DUVOL as dependent variable)

Panel A: Relationship – specific investments				
Variable	(1)	(2)	(3)	(4)
	Low R&D	High R&D	Low R&D	High R&D
SCT_Num	− 0.0063*** (0.002)	0.0001 (0.001)		
SCT_Ratio			− 0.0288* (0.014)	− 0.0109 (0.007)
Constant	0.2256* (0.130)	0.4497** (0.211)	0.2060 (0.125)	0.4561** (0.212)
Control	Y	Y	Y	Y
Industry FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
Industry × Year FE	Y	Y	Y	Y
Chow test	3.52***		2.60***	
N	9024	6426	9024	6426
Adj. R ²	0.0634	0.0447	0.0620	0.0449
Panel B: Switching costs				
Variable	(5)	(6)	(7)	(8)
	Low PCM	High PCM	Low PCM	High PCM
SCT_Num	− 0.0067*** (0.001)	− 0.0030** (0.001)		
SCT_Ratio			− 0.0367*** (0.012)	− 0.0201* (0.010)
Constant	0.1016 (0.155)	− 0.1001 (0.188)	0.0878 (0.154)	− 0.1060 (0.187)
Control	Y	Y	Y	Y
Industry FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
Industry × Year FE	Y	Y	Y	Y
Chow test	1.99**		1.88**	
N	10,701	8485	10,701	8485
Adj. R ²	0.0518	0.0579	0.0508	0.0578

The standard errors (in parentheses) are clustered at the industry level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 17 Heterogeneous effect of different types of supply chain information (with DUVOL as dependent variable)

	(1)	(2)	(3)	(4)	(5)	(6)
SCT_Num_SU	-0.0106*** (0.002)		-0.0107*** (0.003)			
SCT_Num_CU		-0.0065*** (0.002)	0.0001 (0.003)			
SCT_Ratio_SU				-0.0582*** (0.013)		-0.0548*** (0.012)
SCT_Ratio_CU					-0.0261* (0.013)	-0.0073 (0.013)
Constant	0.0912 (0.154)	0.0735 (0.164)	0.0912 (0.156)	0.0783 (0.153)	0.0610 (0.160)	0.0794 (0.155)
Control	Y	Y	Y	Y	Y	Y
Industry FE	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
Industry × Year FE	Y	Y	Y	Y	Y	Y
N	20,870	20,870	20,870	20,870	20,870	20,870
Adj. R ²	0.0537	0.0527	0.0536	0.0532	0.0523	0.0531

The standard errors (in parentheses) are clustered at the industry level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Abbreviations

NMC Health PLC مستشفى المركز الطبي الجديد (In Arabic)

COVID-19 Corona virus disease 2019

SCT Supply chain transparency

CSMAR China stock market and accounting research

CNRDS Chinese research data services

FE Fixed effect

DiD Difference-in-difference

2SLS Two-stage least squares

PSM Propensity score matching

SOE State-owned enterprise

R&D Research and development

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Author contributions

QZ was writing responsible for conceptualization, investigation, and writing of original draft and analysis. QS was responsible for the investigation, and writing of the original draft. C-CL was responsible for the investigation, supervision, visualization, and analysis.

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Availability of data and materials

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Declarations

Ethics approval and consent to participate

This article does not contain any studies with human participants or animals performed by any of the authors.

Competing interests

The authors declare that they have no competing interests.

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