Global NEST Journal, **28** (XX), pp 1-21
Available online: 26/05/2026

How has the IT change affected corporate environmental and social violations in transition economies? Evidence from the supply chain perspective

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Abstract

Corporate entities are the primary drivers of green economic transformation and sustainable development, while information technology can significantly impact corporate environmental and social violations across the supply chain. Therefore, we focus on the impact of information technology change in the supply chain (SITC) on corporate environmental and social violations and explore the mechanisms underlying this effect. Through an empirical analysis of A-share-listed companies in China from 2010 to 2024, we developed a measurement of SITC using computer-assisted textual analysis. The results show that SITC inhibits corporate environmental and social violations through dual mechanisms: 1) enhancing external monitoring capabilities and 2) facilitating knowledge spillover effects. It also significantly affects violations by corporations with high supply chain concentration, lack of government regulation, non-state ownership, and large scale. This research provides evidence on the pathways through which SITC influences corporate environmental and social violations, advancing understanding of how technological change shapes environmental and social accountability challenges.

Keywords: IT change, Corporate violation, Supply chain, Information asymmetry, textual analysis.

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Received: 30/01/2026,

Accepted: 19/05/2026,

Available online: 26/05/2026

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Graphical abstract

1. Introduction

Economic growth often comes with enormous environmental and social costs (Kacperczyk & Peydró, 2022), and thus, economic sustainability is of broad societal interest (Busco *et al.*, 2018). As the most important market players, corporate entities are the primary drivers in advancing green economic transformation and sustainable development (Jia *et al.*, 2019; Burke, 2021). However, corporate environmental and social (E&S) violations remain widespread, especially among industrial firms. Such violations are not merely isolated compliance failures, but also reflect information opacity, insufficient stakeholder monitoring, and governance frictions in firms' operating environments.

Literature has been rich in the antecedents of corporate E&S violations, including (1) the institutional and non-institutional factors outside (Cegarra-Navarro *et al.*, 2013; Liang & Renneboog, 2017; Graafland & Noorderhaven, 2020); (2) the stakeholders internal and external, such as the government, media, investors, consumers, employees, and others (Sonnier *et al.*, 2011; Naughton *et al.*, 2019; Libai *et al.*, 2020); (3) the firm-level features such as size, ownership, and internal governance (Rao & Tilt, 2016; Drempetic *et al.*, 2020; Heese *et al.*, 2022). While this literature has substantially advanced our understanding of why firms violate E&S norms, relatively limited attention has been paid to how changes in the information environment surrounding firms reshape such violations. This omission is important because E&S misconduct is often facilitated by information asymmetry between firms and external stakeholders, particularly in complex supply chain relationships.

Information technology can significantly impact corporate violations. The rapid diffusion of information technologies causes corporations to profoundly change how they operate (Bloom *et al.*, 2014), and it also transmits through the supply chain (Glaeser, 2018). Compared with internet technology, digital technology-based supply chain change (SITC) mitigates information asymmetry in the supply chain by increasing corporations' efficiency in processing upstream and downstream information, such as creditworthiness and reputation (Cabral, 2012; Hollenbeck, 2018; Al-Khatib, 2023). For example, SITC significantly weakens information constraints across supply chains due to limitations imposed by geographic factors (Bernard *et al.*, 2019). Corporations can select business partners with better reputations and higher product quality across a broader range, with greater efficiency (Wang *et al.*, 2018; Goldfarb & Tucker, 2019), thereby promoting optimized resource allocation (Isaksson *et al.*, 2016).

However, existing supply chain literature focuses on the positive and negative impacts on corporate business decisions, while less research has examined the SITC on non-financial decisions such as corporate violations (Kuhn & Mansour, 2014; Bernard *et al.*, 2019). SITC, in this study,

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refers to the application of the new generation of digital technology in the supply chain (Vial, 2019; Braxton & Taska, 2023). Therefore, this study addresses the following questions: Does SITC affect corporate E&S violations? If so, through what mechanisms does this effect occur, and under what conditions is it more pronounced? China provides an appropriate empirical setting for this investigation. As the world's largest transition economy, China faces persistent tensions between industrial development and environmental and social governance. At the same time, Chinese listed firms are deeply embedded in extensive supplier – customer networks, where information frictions between focal firms and their supply chain partners are highly salient. The rapid expansion of China's digital economy also provides substantial cross-firm and over-time variation in SITC.

Based on data from Chinese listed companies from 2010 to 2024, we constructed an SITC measurement using computer-assisted textual analysis to empirically examine the impact of SITC on corporate violations and its mechanisms. The results show that SITC inhibits corporate violations through the external monitoring and knowledge spillover mechanisms, and a series of endogeneity and robustness tests support the conclusions. Moreover, SITC significantly impacts violations of corporations that lack government regulation, have high supply chain concentration, and are large-scale. We also found that downstream customers exerted the monitoring governance effect more effectively than upstream suppliers.

This study makes three contributions to the literature. First, it extends research on the antecedents of corporate E&S violations by introducing SITC as an important information-related determinant. Research on corporate E&S antecedents is relatively abundant, but we should pay more attention to information technology factors in companies' environments (Naughton *et al.*, 2019; Libai *et al.*, 2020). This study expands on the impact of IT change on the corporate environment and development decisions and identifies the key terms of IT change. Second, this study contributes to the literature on supply chain digitalization by documenting its non-financial governance consequences (Bloom *et al.*, 2014; Vial, 2019). This study establishes evidence regarding the pathways through which SITC influences corporate environmental and social violations. Third, this study refines the application of information asymmetry theory in the context of corporate sustainability (Campbell *et al.*, 2012; Blankespoor *et al.*, 2014). SITC improves the efficiency of information processing and mitigates information asymmetry, thereby effectively leveraging stakeholders' monitoring function.

2. Literature and Hypotheses

2.1. *Literature*

2.1.1. *The factors influencing corporate E&S performance*

Literature is rich in the factors influencing corporate E&S performance, including the institutional and non-institutional factors (Cegarra-Navarro *et al.*, 2013; Graafland & Noorderhaven, 2020), internal and external stakeholders (Naughton *et al.*, 2019; Libai *et al.*, 2020) and firm-level factors (Drempetic *et al.*, 2020; Heese *et al.*, 2022). Research suggests that country-level institutional and cultural factors are essential in explaining differences in corporate E&S ratings across countries (Liang & Renneboog, 2017; Graafland & Noorderhaven, 2020). For example, corporate E&S ratings are higher in countries with laws that encourage competition, strong civil liberties and political power, and cultural environments that emphasize harmony and autonomy (Liang & Renneboog, 2017). Graafland & Noorderhaven (2020) also confirmed that the liberal economic system and the long-term orientation culture positively influence corporate E&S performance, and the combined effect is stronger than the individual factors. Meanwhile, stakeholders are also essential. When investors strongly prefer E&S, a valuation premium is given to corporate E&S performance (Naughton *et al.*, 2019). Analyst teams analyze and disseminate information about corporate E&S practices, which is essential in rectifying corporate non-compliance and improving corporate E&S performance (Burke, 2021; Heese *et al.*, 2022). Moreover, firm-level factors also influence their E&S performance. Large-scale firms with significant assets are subject to more public scrutiny and perform better (Drempetic *et al.*, 2020). State-owned enterprises are better at fulfilling their responsibilities than other firms because of their specific duties in socio-economic development (Heese *et al.*, 2022). CEO and corporate governance characteristics, such as board traits, also influence the corporate E&S performance (Rao & Tilt, 2016).

2.1.2. *Economic consequences of information technology change*

IT change has a significant impact on enterprises, including corporate efficiency and performance (Bloom *et al.*, 2014; Mendling *et al.,* 2020), innovation and market value (Kong *et al.*, 2022; Balakrishnan *et al.*, 2014), and the supply chain (Isaksson *et al.*, 2016; Dai *et al.*, 2021). IT change can improve corporate efficiency, and the effect varies significantly across countries (Bloom *et al.*, 2014). Steelman *et al.* (2019) find that investing in information technology improves corporate performance. Mendling *et al.* (2020) find that different types of digitization technologies can help corporations reduce control costs, increase operational efficiency, and enhance their human capital structure, thereby increasing productivity. IT change can also promote corporate innovation. Kong *et al.* (2022) use the sudden termination of Google search service in China to confirm that access to information is an essential driver of technological progress. In terms of capital market performance, Balakrishnan *et al.* (2014) find that corporations' adoption of digital technology alleviates information asymmetry and improves capital market expectations, thereby increasing firm value and financial stability. From the supply chain perspective, IT change has a diffusion effect. Matarazzo *et al.* (2021) find that customers' adoption of digital technology significantly drives IT change in corporations upstream of the supply chain. In addition, the diffusion effect among supply chain corporations is affected by geographic distance, technology gap, and business dependence intensity (Isaksson *et al.*, 2016) and is moderated by external competitive pressure and customer demand (Dai *et al.*, 2021).

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2.2. *Hypotheses*

SITC promotes the efficiency of information transfer between upstream and downstream in the supply chain and mitigates the problem of information asymmetry (Chen *et al.*, 2020), which ultimately reduces corporate violations through the external monitoring mechanism and knowledge spillover mechanism.

SITC can influence corporate violations through the external monitoring mechanism. Unlike Internet technology, SITC, based on digital technology, enables substantial increases in efficiency in managing upstream and downstream creditworthiness, performance records, reputation, and other information, and reduces information asymmetry between external stakeholders and corporations (Cabral, 2012; Hollenbeck, 2018). For example, technologies such as blockchain achieve traceability and non-tampering of supply chain information, ensuring the information in the chain is accurate and reliable and generating spillovers to the external (Goldfarb & Tucker, 2019). Meanwhile, SITC significantly reduces constraints across supply chains due to geographic restrictions, enabling upstream and downstream parties to obtain information at lower cost and higher efficiency (Bernard *et al.*, 2019). It can elevate the risk of hiding lousy news (Cheng *et al.*, 2016) and facilitates the monitoring by external stakeholders (Wang *et al.*, 2018). As a result, SITC reduces corporate moral hazard and opportunistic behaviors like corporate violations (Kuhn & Mansour, 2014; Isaksson *et al.*, 2016).

H1a. As SITC levels increase, corporate violations decrease through external monitoring.

SITC can also influence corporate violations through the knowledge spillover mechanism. SITC facilitates the flow of data, knowledge, and information, conducive to information sharing and knowledge spillover among supply chain members and enhances the learning and exchange of green management experience (Kuhn & Mansour, 2014; Al-Khatib, 2023). Because there is an interdependent relationship between upstream and downstream in the supply chain, such as the products of upstream corporations serving as intermediate inputs for downstream, at this point, SITC drives corporations to break down barriers to factor flows and reach extensive linkages with upstream and downstream, accelerating the transmission and processing efficiency of green product information in the supply chain (Wang *et al.*, 2018; Goldfarb & Tucker, 2019). The information advantage thus created alleviates the operating pressure and financing constraints of cooperative corporations (Cohen & Li, 2020), supports them to optimize resource allocation through green management, and reduces pollution emissions (Li *et al.*, 2018; Kong *et al.*, 2022), thus reducing corporate violations. Therefore, we have the hypotheses:

H1b. As SITC levels increase, corporate violations decrease through knowledge spillover.

3. Method

3.1. *Sample and data source*

We selected data from 2010 to 2024 as the research sample. Referring to existing studies (Chu *et al.*, 2019; Burke, 2021), this study treats the data as follows: (1) exclude ST, PT category and financial industry listed companies; (2) exclude the samples with year-industry observations less than 10; (3) exclude the samples with missing data on the independent and dependent variables; and (4) for the continuous variables used, they are all shrunk at the 1 and 99% levels.

SITC data is derived from the financial reports of listed companies. Given that most suppliers and customers are non-listed firms with no publicly disclosed financial data, we match the sample of observations whose suppliers and customers are listed firms. For example, the listed suppliers and customers (S1, S2, C1, C2) corresponding to a firm (E) in the sample year (201X) have observations E-S1-201X, E-S2-201X, E-C1-201X, and E-C2-201X. However, the sample size is still relatively small, and we refer to the existing research (Chu *et al.*, 2019) to keep the top five suppliers and customers and obtain 3,226 observations from 1,309 listed companies.

3.2. *Measures*

3.2.1. *Independent variables*

The independent variable is SITC (Itc_s). Since text analysis provides accurate measurement and continuous data, it is widely used and recognized (Yang, 2022; Liu *et al.*, 2023), we finally used this method to construct SITC. Text analysis includes constructing a dictionary of IT change, analyzing financial reports, and measuring IT change keywords (Hoberg & Maksimovic, 2015; Buehlmaier & Whited, 2018). We explained the steps and methods in detail in Appendix 2. We also conduct correlation tests for SITC. The comparison indicator is IT expenditures as a share of sales (Itc_i) (Steelman *et al.*, 2019). The correlation results show that Itc_i is significantly positive with Itc_s (β=0.238, $p<0.01$). On this basis, we construct supplier/customer firm-annual data based on supply chain relationships. Considering that data from unlisted firms are difficult to obtain and the sample size is small, we refer to existing studies (Chu *et al.*, 2019) and retain the sample where the top five suppliers and customers are listed firms.

3.2.2. *Dependent variables*

The dependent variable is corporate violations. This study constructs indicators of environmental violations (EQ) and social violations (SQ) based on the IPE and CSMAR databases. Among them, IPE is a non-profit organization that builds a database of corporate environmental violations by using big data technology to capture government information and supplement unofficial data through non-governmental organizations, media, and other channels (Seligsohn *et al.*, 2018). CSMAR collects data on company-related litigation with the events' content, the reasons involved, the awards' content, and the enforcement status (Jia *et al.*, 2019), which overlap with the social pillar of the MSCI ESG rating system. Therefore, we use the natural logarithm of illegal pollution records in the IPE database to construct environmental violations and take the natural logarithm of incidents in the China Listed Companies Litigation and Arbitration Research database to measure corporate social violations.

3.2.3. *Control variables*

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Referring to Jia *et al.* (2019) and Burke (2021), this study controls three types of variables. First, the primary financial characteristics of the firm, which include firm age (Age), the natural logarithm of years the firm has been in existence; firm size (Size), the natural logarithm of the total assets; gearing ratio (Lev), the ratio of total liabilities to total assets; return on assets (Roa), the ratio of net profit to total assets; and Growth (Grow), the ratio of net profit to total assets. Second, corporate governance, including duality (Tio), whether the board of directors and executives hold concurrent positions; the ratio of independent directors (Indep); Top4, whether a Big 4 accounting firm conducts the audit; audit opinion (Report), whether the audit report is a labeled opinion. Moreover, we control city-level variables, like economic (Gdp) and education (Edu), measured by the natural logarithm of the GDP per capita and the number of universities, and control individual (Firm) and year (Year) fixed effects.

3.3. *Modeling*

We constructed the following basic regression model to examine how the SITC impacts E&S violation (1).

$$Violation_{i,t} = \beta_0 + \beta_1 Itc\_s_{i,t} + \beta_c \sum Control_{i,t} + \mu_i + \nu_t + \varepsilon_{i,t} \quad (1)$$

Where $Violation_{i,t}$ denotes corporate violations, which has two dimensions: environmental violations (EQ) and social violations (SQ); $Itc\_s_{i,t}$ is an indicator of SITC. $Control_{i,t}$ in the model contains the following control variables: year of establishment (Age), firm size (Size), gearing ratio (Lev), return on assets (Roa), growth (Grow), two jobs in one (Tio), proportion of sole directors (Indep), whether Big 4 audited (Top4), Big 4 audit opinion (Report), city economic level (Gdp), city education level (Edu), and individual (Firm) and year (Year) fixed effects. In addition, $\varepsilon_{i,t}$ are randomized disturbance terms.

4. Results

4.1. *Descriptive statistics and Pearson correlations*

Table 1 presents detailed descriptive statistics for the variables. The mean values of environmental violations (EQ) and social violations (SQ) are 0.247 and 0.147; the maximum values are 2.833 and 2.303, and the minimum values are 0.000, suggesting significant variation in violations across firms. The mean value of the independent variable SITC (Itc_s) is 0.1% (i.e., one occurrence of the keyword in a 1,000-word report), and the maximum value is 1.5%, while the minimum value is 0.000, which indicates that there are significant differences in SITC. Moreover, no obvious abnormality in the financial and governance variables suggests a reasonable sample.

Table 1. Descriptive statistics.

Variable	Obs	Mean	Std. Dev.	Min	Max
EQ	3,226	0.247	0.574	0.000	2.833
SQ	3,226	0.147	0.430	0.000	2.303
Itc_s	3,226	0.001	0.003	0.000	0.015
Age	3,226	2.767	0.372	1.609	3.466
Size	3,226	21.891	1.253	19.790	25.557
Lev	3,226	0.406	0.210	0.041	0.891
Roa	3,226	0.042	0.059	-0.208	0.191
Grow	3,226	0.157	0.319	-0.489	1.675
Tio	3,226	0.241	0.427	0.000	1.000
Indep	3,226	0.367	0.048	0.333	0.556
Top4	3,226	0.033	0.177	0.000	1.000
Report	3,226	0.969	0.173	0.000	1.000
Gdp	3,226	10.799	2.717	0.000	13.135
Edu	3,226	2.845	1.326	0.000	4.533

Table 2. Results of Pearson correlation coefficient.

Variables	(1)	(2)	(3)
(1)EQ	1.000		
(2)SQ	0.046***	1.000	
(3)Itc_s	-0.074***	-0.010**	1.000

Notes: * *p<0.10;* ** *p<0.05;* *** *p<0.01.*

Table 2 presents the Pearson correlation coefficients for the variables. We can see that the Pearson correlation coefficients between SITC (Itc_s) and EQ (β=-0.074, p<0.01) and SQ (β=-0.010, p<0.05) are all significantly negative, so we verified Hypothesis 1 preliminarily. However, it is yet to be followed up by subsequent tests. Besides, the absolute values of correlation coefficients between independent and control variables are less than 0.200. The average VIF is 1.300, and the maximum is 1.800, both of which are well below 10. Therefore, there is no need to worry about serious multicollinearity among the variables.

4.2. *Main effect*

Table 3 lists the regression results for the main effect. This section uses the fixed effects model concerning Model 1, and Columns (2) and (4) show the results of the regression of SITC on corporate E&S violations. The results in columns (2) and (4) show that SITC significantly inhibits corporate environmental violations (β=-0.180, p<0.01) and social violations (β=-0.073, p<0.05). In terms of economic significance, a 1% increase in the degree of SITC can reduce approximately 0.180 environmental violations and 0.073

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social violations. In summary, SITC exhibits a dampening effect on corporate violations, and main effect is supported.

The results have clear economic implications. Holding other factors constant, an increase in SITC is associated with fewer corporate violations, suggesting that digital changes embedded in supply chain relationships can discipline firms' sustainability-related behavior. The effect is stronger for environmental violations than for social violations. This finding is consistent with studies showing that information technology reduces information frictions and improves interfirm coordination (Bloom *et al.*, 2014; Goldfarb & Tucker, 2019). It also extends the supply chain literature by showing that SITC has governance consequences beyond operational efficiency and market performance.

For the control variables, year of establishment (Age), gearing ratio (Lev), return on assets (Roa), standard audit opinion (Report), and urban education level (Edu) have a significant effect on corporate violations. Long-established firms have more violations disclosed because large firms usually receive more public attention and are assigned higher social expectations (Drempetic *et al.*, 2020); firms with low gearing and high return on assets have spare resources to fulfill their responsibilities and fewer violations (Cohen & Li, 2020); standard audit opinions and higher levels of urban education are conducive to reducing corporate violations (Ke *et al.*, 2015).

Table 3. Results of main effect.

	(1)	(2)	(3)	(4)
VARIABLES	***EQ***	***EQ***	***SQ***	***SQ***
Itc_s		-0.180***		-0.073**
		(-5.068)		(-2.501)
Age	0.062**	0.056*	0.120***	0.118***
	(2.108)	(1.900)	(4.920)	(4.814)
Size	0.194***	0.190***	-0.002	-0.004
	(21.046)	(20.565)	(-0.298)	(-0.529)
Lev	0.156***	0.140**	0.140***	0.133***
	(2.747)	(2.465)	(2.979)	(2.835)
Roa	-0.040	-0.027	-0.303**	-0.298*
	(-0.216)	(-0.149)	(-1.991)	(-1.959)
Grow	-0.013	-0.003	-0.019	-0.015
	(-0.433)	(-0.104)	(-0.785)	(-0.622)
Tio	0.005	0.013	-0.001	0.003
	(0.253)	(0.608)	(-0.034)	(0.141)
Indep	-0.256	-0.262	0.514***	0.511***
	(-1.397)	(-1.436)	(3.393)	(3.380)
Top4	0.122**	0.120**	-0.004	-0.005
	(2.393)	(2.358)	(-0.089)	(-0.111)
Report	0.066	0.072	-0.277***	-0.274***
	(1.263)	(1.386)	(-6.435)	(-6.379)
Gdp	0.001	0.000	0.003	0.003
	(0.135)	(0.088)	(0.967)	(0.944)
Edu	-0.026***	-0.017**	-0.010	-0.006
	(-3.166)	(-2.054)	(-1.388)	(-0.838)
Constant	-4.140***	-4.026***	-0.109	-0.062
	(-18.984)	(-18.435)	(-0.603)	(-0.343)
Year Fixed Effect	Yes	Yes	Yes	Yes
Firm Fixed Effect	Yes	Yes	Yes	Yes
Observations	3,226	3,226	3,226	3,226
R^2	0.231	0.237	0.045	0.047
ΔR^2	-	0.006	-	0.002

*Notes: The t-test results are shown in parentheses, and *, **, *** indicate significance at 0.1, 0.05, and 0.01 levels.*

4.3. *Endogeneity tests*

This study focuses on the impact of SITC on corporate violations. To address endogeneity in this study, we use Heckman's two-stage modeling and propensity score matching to address selection bias, and the instrumental variable method to address omitted-variable bias.

4.3.1. *Heckman selection model*

For this study, the most critical endogeneity problem is sample selection bias: high-quality firms generally have higher SITC scores and are usually better able to fulfill their E&S responsibilities. Therefore, we follow Heckman (1979) and use a two-stage model to mitigate the endogeneity due to selection bias. Initially, a probit model is employed to examine the association between firm characteristics and SITC to estimate the inverse Mills ratio (IMR). Firm characteristic indicators encompass establishment duration (Age), firm scale (Size), leverage ratio (Lev), asset profitability (Roa), growth potential (Grow), and ownership structure (Owner). Subsequently, the IMR is incorporated into the

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regression to address potential sample selection bias. As presented in **Table 4,** the regression outcomes demonstrate the statistical significance of IMR across columns 1-4 at the 1% threshold, substantiating the endogeneity stemming from sample selection. However, SITC still shows inhibitory effects on environmental violations (*β=-0.164， p<0.01*) and social violations (*β=-0.064， p<0.05*). Therefore, the findings remain robust.

Table 4. Results of the heckman selection model

	(1)	(2)
VARIABLES	***EQ***	***SQ***
Itc_s	-0.164***	-0.064**
	(-4.864)	(-2.177)
Imr	3.322***	2.172***
	(18.648)	(3.981)
Age	1.744***	1.623***
	(18.405)	(4.283)
Size	1.223***	0.096***
	(21.803)	(3.655)
Lev	1.258***	0.155***
	(15.601)	(3.281)
Roa	-2.962***	-4.498***
	(-12.598)	(-4.220)
Grow	-0.169***	-0.039
	(-5.746)	(-1.538)
Tio	0.032	-0.092***
	(1.547)	(-3.099)
Indep	-5.096***	2.415***
	(-16.337)	(4.816)
Top4	0.374***	-0.022
	(7.447)	(-0.521)
Report	0.793***	-1.372***
	(12.658)	(-4.915)
Gdp	-0.009**	-0.009*
	(-2.218)	(-1.919)
Edu	-0.230***	-0.031***
	(-16.471)	(-3.293)
Constant	-35.121***	-9.359***
	(-20.901)	(-3.996)
Year Fixed Effect	Yes	Yes
Firm Fixed Effect	Yes	Yes
Observations	3,226	3,226
R^2	0.312	0.052
ΔR^2	0.075	0.005

*Notes: The t-test results are shown in parentheses, and *, **, *** indicate significance at 0.1, 0.05, and 0.01 levels. ΔR^2, the last line of the table, is the result compared to Model 2 and 4 in **Table 3**.*

4.3.2. *Propensity score matching*

Besides the Heckman two-stage model, propensity score matching can mitigate endogeneity problems due to selection bias. Therefore, we refer to Caliendo & Kopeinig (2008) and utilize propensity score matching to mitigate potential endogeneity concerns. The method comprises: (1) computation of propensity scores derived from control variables, with the treatment cohort comprising firms ranked within the highest SITC quartile; (2) implementation of a nearest-neighbor matching protocol to establish correspondences between samples; (3) re-estimation of regression models using the matched pairs. **Table 5** (Panel A) shows that univariate mean comparisons reveal negligible disparities in financial characteristic metrics between cohorts. Results in **Table 5** (Panel B) confirm the robustness of propensity score matching through standardizing the matched sample: SITC still exhibits a dampening effect on environmental violations (*β=-0.180， p<0.01*) and social violations (*β=-0.073， p<0.05*). Therefore, the findings remain robust after propensity score matching.

4.3.3. *Instrumental variable*

This study controls financial and governance characteristics and city-level variables, but endogeneity may arise due to omitted variables. Therefore, we refer to Nunn & Qian (2014) to mitigate endogeneity using instrumental variables based on 1984 postal and telecommunication data for the prefecture-level cities where supply chain firms are. Theoretically, the communication methods of cities in the process of development will affect the application of new-generation IT by local enterprises and thus satisfy the relevance condition; post and telecommunications, as an information infrastructure, mainly provide daily

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communication services for the residents of the relevant region and do not directly play a role in the violations of enterprises, and satisfy the exogeneity condition (Nunn & Qian, 2014). Considering that the number of posts and telecommunications in 1984 is cross-sectional data, this study constructs a cross-multiplier term (Terrain) as a final instrumental variable that multiplies the percentage of the population with Internet access in each province in the previous year by the number of post offices in the locations of supply chain firms. **Table 6** reports the results of the instrumental variables method. The regression coefficients of the instrumental variables in column (1) are significantly positive (*β=0.018, p<0.01*), indicating that they satisfy the correlation condition; the results in columns (2) and (3) show that the SITC inhibitory effects on corporate environmental violations (*β=-0.193, p<0.01*) and social violations (*β*=-0.074, *p*<0.05) remain robust.

4.4. *Other robustness tests*

Besides the endogeneity test, we also apply other robustness tests for the conclusions, including alternative measures of variables, and exclude the interference of Internet factors.

4.4.1. *Alternative measures of IT change*

Considering the differences in the literature on the definition of IT change, we refer to Steelman *et al.* (2019) and Braxton & Taska (2023) and use the $\Delta IT_{i,t}$ to construct SITC. **Table 7** presents the results of alternative measures of the dependent variable. This section uses a fixed effects model. Column (1) indicates that SITC (*β=-0.075, p<0.10*) significantly inhibits corporate environmental violations, and column (2) indicates that SITC (*β=-0.107, p<0.01*) significantly inhibits corporate social violations. The results indicate that the findings remain robust.

Table 5. Results of propensity score matching.

Panel A: Results of univariate mean difference test				
	Mean after matching	**Difference**	**T value**	
	Treat group	**Control group**		
Age	2.929	2.930	-0.002	-0.040
Size	22.909	22.880	0.023	0.380
Lev	0.516	0.534	-0.090	-1.590
Roa	0.030	0.018	0.207	3.420*
Grow	0.139	0.142	-0.010	-0.016
Tio	0.161	0.153	0.019	0.390
Indep	0.362	0.365	-0.067	-1.230
Owner	0.564	0.583	-0.039	-0.680
Panel B: Results of propensity score matching				
		(1)		**(2)**
VARIABLES		***EQ***		***SQ***
Itc_s		-0.180***		-0.073**
		(-5.068)		(-2.501)
Age		0.056*		0.118***
		(1.900)		(4.814)
Size		0.190***		-0.004
		(20.565)		(-0.529)
Lev		0.140**		0.133***
		(2.465)		(2.835)
Roa		-0.027		-0.298*
		(-0.149)		(-1.959)
Grow		-0.003		-0.015
		(-0.104)		(-0.622)
Tio		0.013		0.003
		(0.608)		(0.141)
Indep		-0.262		0.511***
		(-1.436)		(3.380)
Top4		0.120**		-0.005
		(2.358)		(-0.111)
Report		0.072		-0.274***
		(1.386)		(-6.379)
Gdp		0.000		0.003
		(0.088)		(0.944)
Edu		-0.017**		-0.006
		(-2.054)		(-0.838)
Constant		-4.026***		-0.062
		(-18.435)		(-0.343)
Year Fixed Effect		Yes		Yes

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Firm Fixed Effect	Yes	Yes
Observations	3,226	3,226
R^2	0.237	0.047

*Notes: The t-test results are shown in parentheses, and *, **, *** indicate significance at 0.1, 0.05, and 0.01 levels.*

Table 6. Results of instrumental variable.

	(1)	(2)	(3)
VARIABLES	***Itc_s***	***EQ***	***SQ***
Itc_s		-0.193***	-0.074**
		(-7.001)	(-2.542)
Terrain	0.018***		
	(26.810)		
Controls	Yes	Yes	Yes
Constant	-5.099***	-51.889***	-34.631***
	(-2.561)	(-7.188)	(-6.179)
Year Fixed Effect	Yes	Yes	Yes
Firm Fixed Effect	Yes	Yes	Yes
Cragg-Donald Wald F	71.852***		
Observations	3,226	3,226	3,226
R^2	0.890	0.270	0.087

*Notes: The t-test results are shown in parentheses, and *, **, *** indicate significance at 0.1, 0.05, and 0.01 levels.*

Table 7. Results of alternative measures of IT change.

	(1)	(3)
VARIABLES	***EQ***	***SQ***
Itc_sr	-0.075*	-0.107***
	(-1.679)	(-2.915)
Age	0.062**	0.120***
	(2.095)	(4.903)
Size	0.194***	-0.003
	(20.986)	(-0.393)
Lev	0.155***	0.138***
	(2.722)	(2.938)
Roa	-0.053	-0.323**
	(-0.289)	(-2.118)
Grow	-0.012	-0.017
	(-0.390)	(-0.710)
Tio	0.008	0.002
	(0.345)	(0.127)
Indep	-0.255	0.516***
	(-1.390)	(3.411)
Top4	0.121**	-0.006
	(2.366)	(-0.136)
Report	0.065	-0.277***
	(1.255)	(-6.455)
Gdp	0.001	0.003
	(0.137)	(0.970)
Edu	-0.025***	-0.008
	(-3.056)	(-1.206)
Constant	-4.128***	-0.092
	(-18.929)	(-0.514)
Year Fixed Effect	Yes	Yes
Firm Fixed Effect	Yes	Yes
Observations	3,226	3,226
R^2	0.231	0.048

*Notes: The t-test results are shown in parentheses, and *, **, *** indicate significance at 0.1, 0.05, and 0.01 levels.*

4.4.2. *Alternative measures of violation*

Unlike the natural logit measure in the main effects, this section uses absolute numbers and whether a violation occurred for robustness testing (Burke, 2021). The results in **Table 8** show that SITC has a significant inhibitory effect on the number (β*=-0.519, p<0.01*) and occurrence (β*=-0.149,*

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p<0.01) of environmental violations and a negative inhibitory impact on the number (*β=-0.195, p<0.05*) and occurrence (*β=-0.066, p<0.01*) of social violations. The results suggest that the findings remain robust after alternative measures.

4.4.3. *Exclusion of Internet effect*

This study defines IT change as new-generation technology, removing the part of Internet technology from digital technology. However, Internet technology can impact corporate violations (Forman & Zeebroeck, 2012). Therefore, this section measures the level of Internet technology in the city where the firms are and adds it to the model as a control variable. The results in **Table 9** show that the regression coefficients of SITC on environmental violations in columns (1) and (3) are significantly negative at the 1% level, those on social violations in columns (2) and (4) are significantly negative at the 5% level. The results indicate that the findings remain robust after excluding the effect of Internet technology.

4.4.4. *Increasing the sample size*

In this section, we constructed an alternative measure that captures SITC in firms' external infrastructure, rather than relying only on matched listed suppliers and customers (Zhu & Li, 2024). It is closely related to our main explanatory variable because both measures capture changes in the information conditions under which firms interact with external stakeholders. However, this alternative measure does not require supplier and customer firms to be listed. Therefore, it allows us to expand the sample size. The results in **Table 10** show that SITC in firms' external infrastructure has a significant inhibitory effect on the environmental violations (*β=-0.139, p<0.01*) and a significant inhibitory impact on social violations (*β=-0.085, p<0.01*). The results suggest that the findings remain robust after increasing the sample size.

Table 8. Results of alternative measures of violation

	(1)	(2)	(3)	(4)
VARIABLES	***EQ***	***SQ***	***EQ***	***SQ***
Itc_s	-0.519***	-0.195**	-0.149***	-0.066***
	(-3.622)	(-2.188)	(-5.821)	(-2.826)
Age	0.099	0.326***	0.056***	0.086***
	(0.830)	(4.399)	(2.640)	(4.457)
Size	0.740***	-0.034	0.103***	0.002
	(19.806)	(-1.473)	(15.402)	(0.410)
Lev	0.284	0.528***	0.106***	0.038
	(1.239)	(3.706)	(2.590)	(1.016)
Roa	0.065	-0.433	-0.063	-0.379***
	(0.088)	(-0.938)	(-0.477)	(-3.146)
Grow	-0.048	-0.073	-0.008	-0.007
	(-0.402)	(-0.984)	(-0.390)	(-0.338)
Tio	0.009	0.013	0.008	-0.009
	(0.104)	(0.231)	(0.531)	(-0.666)
Indep	-0.784	1.359***	-0.294**	0.277**
	(-1.062)	(2.961)	(-2.227)	(2.317)
Top4	0.572***	-0.082	0.079**	0.003
	(2.775)	(-0.641)	(2.144)	(0.079)
Report	0.152	-0.793***	0.077**	-0.195***
	(0.723)	(-6.088)	(2.055)	(-5.737)
Gdp	0.014	0.020**	-0.001	-0.000
	(0.844)	(1.996)	(-0.415)	(-0.140)
Edu	-0.057*	-0.040*	-0.011*	-0.001
	(-1.677)	(-1.897)	(-1.796)	(-0.268)
Year/Firm Fixed	Yes	Yes	Yes	Yes
Observations	3,226	3,226	3,226	3,226
R2	0.197	0.044	0.183	0.040

*Notes: The t-test results are shown in parentheses, and *, **, *** indicate significance at 0.1, 0.05, and 0.01 levels. Columns (1) and (2) are the results of absolute numbers, while Columns (3) and (4) are the results of whether or not an violation occurred.*

5. Further verification

5.1. *Mechanism test*

5.1.1. *External monitoring mechanism*

SITC reduces information asymmetry in the supply chain by weakening the information constraints due to geographic constraints (Bernard *et al.*, 2019), allowing firms to access information in the supply chain at a lower cost and with greater efficiency (Cabral, 2012; Hollenbeck, 2018), which makes it more costly for firms to hide lousy news (Cheng *et al.*, 2016) and can reduce corporate violations (Kuhn & Mansour, 2014; Isaksson *et al.*, 2016). Therefore, this section tests the mechanism by firm-level Baidu index (Baidu) and information asymmetry (Asym). **Table 11** shows the results of the external monitoring mechanism. Column (1) shows

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the result of SITC on the Baidu index (β=0.711, p<0.01) is significantly positive, and column (2) indicates the result of SITC on information asymmetry (β=-0.166, p<0.01) is significantly negative.

These results support the external monitoring mechanism. When supply chain information becomes more transparent and easier to process, external stakeholders can better observe firm behavior and identify potential misconduct (Hollenbeck, 2018). Increased visibility raises the expected cost of hiding bad news and engaging in E&S violations (Isaksson *et al.*, 2016). Therefore, SITC reduces corporate violations by strengthening external governance pressure.

Table 9. Results of exclusion of Internet effect.

	(1)	(2)	(3)	(4)
Variables	***EQ***	***EQ***	***SQ***	***SQ***
Itc_s	-0.144***	-0.181***	-0.076**	-0.073**
	(-3.942)	(-5.109)	(-2.508)	(-2.487)
Iti_s	-19.279***		1.589	
	(-3.647)		(0.362)	
Inter		-0.016		0.003
		(-1.084)		(0.257)
Age	0.054*	0.053*	0.118***	0.118***
	(1.842)	(1.802)	(4.819)	(4.818)
Size	0.192***	0.190***	-0.004	-0.004
	(20.763)	(20.557)	(-0.547)	(-0.527)
Lev	0.123**	0.140**	0.135***	0.133***
	(2.170)	(2.462)	(2.855)	(2.835)
Roa	-0.067	-0.026	-0.295*	-0.299*
	(-0.363)	(-0.142)	(-1.934)	(-1.960)
Grow	-0.002	-0.002	-0.015	-0.015
	(-0.076)	(-0.078)	(-0.625)	(-0.628)
Tio	0.016	0.011	0.002	0.003
	(0.746)	(0.510)	(0.127)	(0.162)
Indep	-0.271	-0.263	0.512***	0.511***
	(-1.485)	(-1.441)	(3.384)	(3.380)
Top4	0.116**	0.117**	-0.004	-0.004
	(2.284)	(2.304)	(-0.103)	(-0.098)
Report	0.068	0.073	-0.274***	-0.274***
	(1.315)	(1.409)	(-6.370)	(-6.382)
Gdp	0.001	0.000	0.003	0.003
	(0.169)	(0.052)	(0.935)	(0.951)
Edu	-0.014*	-0.017**	-0.006	-0.006
	(-1.705)	(-2.035)	(-0.869)	(-0.843)
Constant	-4.044***	-4.010***	-0.061	-0.065
	(-18.550)	(-18.322)	(-0.335)	(-0.360)
Year Fixed Effect	Yes	Yes	Yes	Yes
Firm Fixed Effect	Yes	Yes	Yes	Yes
Observations	3,226	3,226	3,226	3,226
R^2	0.240	0.237	0.047	0.047

*Notes: The t-test results are shown in parentheses, and *, **, *** indicate significance at 0.1, 0.05, and 0.01 levels.*

5.1.2. *Knowledge spillover mechanism*

SITC facilitates information sharing and knowledge flow between upstream and downstream firms in the supply chain, accelerates their knowledge transfer and processing efficiency, and promotes their learning of green management-related knowledge (Kuhn & Mansour, 2014; Goldfarb & Tucker, 2019). It supports collaborating corporations in optimizing resource allocation through green management, reducing pollution emissions (Li *et al.*, 2018; Kong *et al.*, 2022), thereby reducing corporate violations. Therefore, this section takes the total amount of green innovation (Green_t) and the quality of green innovation (Green_i) of enterprises as the influencing mechanism variables. **Table 12** presents the results.

Column (1) shows that the regression coefficient of SITC on the total amount of green innovation (β=0.095, p<0.01) is significantly positive, and column (2) shows that the regression coefficient of SITC on the quality of green innovation (β=0.176, p<0.01) is significantly positive. The results support the knowledge spillover mechanism. SITC enables firms to absorb and apply sustainability-related knowledge from supply chain partners. This strengthens their green innovation capacity and reduces the likelihood of environmental and social misconduct. This finding

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complements the external monitoring mechanism. SITC reduces violations through both a pressure-based channel and a capability-based channel. In other words, digitalized supply chain relationships not only make misconduct more visible and costly, but also provide firms with the knowledge resources to avoid such misconduct (Goldfarb & Tucker, 2019; Kong *et al.*, 2022).

Table 10. Results of increasing the sample size.

	(1)	(2)
VARIABLES	***EQ***	***SQ***
Itc_s	-0.139***	-0.085***
	(-2.813)	(-3.647)
Age	0.307***	0.074*
	(7.444)	(1.763)
Size	0.077***	0.001
	(11.040)	(0.129)
Lev	-0.100***	0.149***
	(-3.485)	(5.067)
Roa	-0.015	-0.290***
	(-0.257)	(-4.815)
Grow	-0.012	-0.030***
	(-1.593)	(-3.855)
Tio	0.001	-0.013
	(0.107)	(-1.434)
Indep	0.096	0.216***
	(1.236)	(2.714)
Top4	-0.050*	-0.066**
	(-1.845)	(-2.362)
Report	-0.017	-0.251***
	(-0.927)	(-13.699)
Gdp	-0.007	-0.056***
	(-0.564)	(-4.228)
Edu	-0.071***	0.031*
	(-4.509)	(1.911)
Constant	-27.948***	-37.037***
	(-4.979)	(-6.447)
Year Fixed Effect	Yes	Yes
Firm Fixed Effect	Yes	Yes
Observations	30,482	30,482
R^2	0.092	0.056

*Notes: The t-test results are shown in parentheses, and *, **, *** indicate significance at 0.1, 0.05, and 0.01 levels.*

Table 11. Results of external monitoring mechanism.

	(1)	(5)
VARIABLES	***Baidu***	***Asym***
Itc_e	0.711***	-0.166***
	(4.554)	(-4.639)
Age	-0.263*	-0.081**
	(-1.882)	(-2.525)
Size	0.494***	-0.235***
	(11.313)	(-23.411)
Lev	-0.957***	0.345***
	(-3.559)	(5.594)
Roa	3.333***	0.153
	(3.829)	(0.767)
Grow	-0.645***	0.010
	(-4.614)	(0.321)
Tio	0.419***	-0.015
	(4.083)	(-0.616)
Indep	1.482*	-0.463**
	(1.714)	(-2.332)
Top4	0.020	0.010
	(0.081)	(0.175)

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Report	0.044	0.078
	(0.177)	(1.388)
Gdp	0.061***	0.001
	(3.209)	(0.148)
Edu	-0.062	0.004
	(-1.540)	(0.485)
Constant	-6.992***	5.187***
	(-6.765)	(21.861)
Year Fixed Effect	Yes	Yes
Firm Fixed Effect	Yes	Yes
Observations	3,226	3,219
Adj.R^2	0.085	0.171

*Notes:The t-test results are shown in parentheses, and *, **, *** indicate significance at 0.1, 0.05, and 0.01 levels.*

5.2. *Moderating effect*

SITC helps to reduce information asymmetry in the supply chain (Cabral, 2012; Hollenbeck, 2018) and facilitates deep partnerships between upstream and downstream firms (Goldfarb & Tucker, 2019), influencing the impact of SITC on corporate E&S violations. Referring to Jiang *et al.* (2023), this study measures supply chain concentration (Supply) using the Top 5 customer and supplier concentration. Therefore, this study tests the moderating role of supply chain concentration through cross-multiplier terms in model 2 (Isaksson *et al.*, 2016).

$$Violation_{i,t} = \beta_0 + \beta_1 Itc\_s_{i,t} + \beta_2 Supply_{i,t} + \beta_3 Itc\_s_{i,t} * Supply_{i,t} + \beta_c \sum Control_{i,t} + \mu_i + \nu_t + \varepsilon_{i,t} \quad (2)$$

Where $Violation_{i,t}$ denotes corporate violations, which has three dimensions: environmental violations (EQ) and social violations (SQ); $Itc\_s_{i,t}$ is an indicator of SITC. $Supply_{i,t}$ is the moderating variable, $Itc\_s_{i,t}$* $Supply_{i,t}$ is the standardized cross-multiplier term. $Control_{i,t}$ in the model contains the following control variables: year of establishment (Age), firm size (Size), gearing ratio (Lev), return on assets (Roa), growth (Grow), two jobs in one (Tio), proportion of sole directors (Indep), whether Big 4 audited (Top4), Big 4 audit opinion (Report), city economic level (Gdp), city education level (Edu), and individual (Firm) and year (Year) fixed effects. In addition, $\varepsilon_{i,t}$ are randomized disturbance terms.

Table 13 presents the results of the moderating effect of supply chain concentration. The results in column (2) show that the inhibitory effect of SITC on environmental violations is more potent in higher supply chain concentration (*β=-0.031, p<0.01*); the results in column (4) show that the regression coefficient of SITC on social violations (*β=-0.000, p>0.10*) is not significant but still negative in higher supply chain concentration, although it is not significant still negative. Thus, the results partly confirm the moderating effect of supply chain concentration.

Table 12. Results of knowledge spillover mechanism.

	(1)	**(2)**
VARIABLES	***Green_t***	***Green_i***
Itc_e	0.095*	0.176***
	(1.755)	(4.313)
Age	-0.241***	-0.166***
	(-4.969)	(-4.541)
Size	0.187***	0.136***
	(12.323)	(11.916)
Lev	0.185**	0.010
	(1.987)	(0.138)
Roa	-0.300	-0.165
	(-0.993)	(-0.728)
Grow	0.057	0.041
	(1.176)	(1.131)
Tio	0.084**	0.061**
	(2.374)	(2.291)
Indep	0.019	-0.056
	(0.062)	(-0.247)
Top4	0.261***	0.207***
	(3.124)	(3.298)
Report	0.331***	0.176***
	(3.887)	(2.750)
Gdp	0.011	0.005
	(1.619)	(1.036)
Edu	0.042***	0.037***

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	(3.025)	(3.556)
Constant	-3.580***	-2.587***
	(-9.986)	(-9.597)
Year Fixed Effect	Yes	Yes
Firm Fixed Effect	Yes	Yes
Observations	3,226	3,226
Adj.R²	0.102	0.095

*Notes: The t-test results are shown in parentheses, and *, **, *** indicate significance at 0.1, 0.05, and 0.01 levels.*

Table 14. Heterogeneity test of government supervision.

	(1)	(2)	(3)	(4)
VARIABLES	***EQ***	***EQ***	***SQ***	***SQ***
Itc_s	-0.179***	-0.234**	-0.120***	0.045
	(-4.685)	(-2.536)	(-3.566)	(0.741)
Age	0.058*	0.063	0.162***	0.017
	(1.703)	(1.058)	(5.343)	(0.443)
Size	0.194***	0.195***	-0.025***	0.033***
	(17.775)	(10.338)	(-2.598)	(2.686)
Lev	0.079	0.239**	0.166***	0.013
	(1.215)	(1.976)	(2.869)	(0.163)
Roa	-0.005	-0.040	-0.225	-0.436
	(-0.026)	(-0.096)	(-1.244)	(-1.592)
Grow	0.018	-0.063	0.005	-0.106**
	(0.562)	(-0.975)	(0.176)	(-2.488)
Tio	0.013	-0.013	0.013	-0.019
	(0.543)	(-0.255)	(0.640)	(-0.553)
Indep	-0.173	-0.647	0.392**	0.400
	(-0.848)	(-1.576)	(2.175)	(1.472)
Top4	0.214***	0.099	-0.049	0.013
	(3.050)	(1.231)	(-0.791)	(0.253)
Report	0.015	0.221**	-0.322***	-0.137*
	(0.260)	(1.979)	(-6.244)	(-1.852)
Gdp	-0.005	0.011	-0.002	0.007
	(-0.988)	(1.453)	(-0.557)	(1.287)
Edu	-0.016*	-0.023	-0.003	-0.009
	(-1.717)	(-1.218)	(-0.413)	(-0.725)
Constant	-4.024***	-4.314***	0.415*	-0.719**
	(-15.741)	(-9.527)	(1.837)	(-2.399)
Year Fixed Effect	Yes	Yes	Yes	Yes
Firm Fixed Effect	Yes	Yes	Yes	Yes
Observations	2,339	887	2,339	887
R^2	0.250	0.242	0.064	0.048

*Notes: The t-test results are shown in parentheses, and *, **, *** indicate significance at 0.1, 0.05, and 0.01 levels. Columns (1) and (3) are the results of firms that lack government regulation, while Columns (2) and (4) are the results of government-regulated firms.*

5.3. *Heterogeneity tests*

5.3.1. *Heterogeneity of government supervision*

As a critical stakeholder, the government can exert external governance over firms (Kedia & Rajgopal, 2011), thereby influencing the impact of SITC on corporate violations. Therefore, this study categorizes the sample into two groups based on whether the officials inspect the firms (Jia *et al.*, 2019). **Table 14** presents the heterogeneity test of government regulation. The results in columns (1) and (2) show that the moderating effect of SITC is more significant (*β=-0.179, p<0.01*) in inhibiting environmental violations in firms that lack government regulation compared to government-regulated firms (*β=-0.234, p<0.05*). The results in columns (3) and (4) show that the inhibitory effect of SITC on social violations of firms lacking government regulation is more significant (*β=-0.120, p<0.01*) compared to government-regulated firms (*β=0.045, p>0.10*). Therefore, the results confirm the moderating effect.

5.3.2. *Heterogeneity of firm size*

Large-scale firms, which have broader stakeholder constituencies and face stricter institutional regulation and public scrutiny than small ones (Drempetic *et al.*, 2020), lose legitimacy and experience severe crises when E&S breaches occur (Kölbel *et al.*, 2017), a risk that is amplified by SITC. Therefore, this study tests the moderating role of firm size by dividing the sample into two groups, large-scale and small-scale firms, based on the median asset (Drempetic *et al.*, 2020). **Table 15** presents the heterogeneity test of firm

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size. The results show the inhibitory effect of SITC on large-scale firms' environmental violations is more significant (*β=-0.219, p<0.01*) compared to small-scale firms (*β=-0.082, p<0.01*). The results in columns (3) and (4) show that, compared to small-scale firms (*β=-0.033, p>0.10*), the SITC has a more substantial inhibitory effect on governance violations in large-scale firms (*β=-0.115, p<0.05*). So, the results confirm the moderating effect of firm size.

5.3.3. *Heterogeneity of property rights*

Compared with state-owned enterprises, non-state-owned enterprises usually receive less direct government supervision and public attention (Heese *et al.*, 2022). As a result, they may face greater information opacity and weaker external governance pressure. Under such conditions, SITC can play a more effective governance role by improving transparency of information, strengthening external monitoring, and increasing the expected cost of E&S misconduct. Therefore, this study tests the moderating role of firm size by dividing the sample into two groups, non-state-owned enterprises and state-owned enterprises (Jia *et al.*, 2019). **Table 16** presents the heterogeneity test under different property rights conditions. The results show the inhibitory effect of SITC on non-state-owned firms' environmental violations is more significant (*β=-0.165, p<0.01*). The results in columns (2) and (4) show that, compared to state-owned (*β=-0.117, p<0.10*), the SITC has a more substantial inhibitory effect on governance violations in non-state-owned firms (*β=-0.069, p<0.05*). So, the results confirm the moderating effect of property rights.

5.4. *Upstream and downstream differences*

This section will examine the differences between customers and suppliers. Although upstream and downstream firms in the supply chain can effectively exert supervisory governance effects through their influence and deterrence to improve partners' internal monitoring systems and governance levels, this impact is not symmetrical (Dhaliwal *et al.*, 2016). Therefore, we divide the sample into two groups of customers and suppliers to check the difference.

Table 15. Heterogeneity test of firm size.

	(1)	(2)	(3)	(4)
VARIABLES	**EQ**	**EQ**	**SQ**	**SQ**
Itc_s	-0.219***	-0.082***	-0.115**	-0.033
	(-3.129)	(-3.418)	(-2.216)	(-0.984)
Age	0.098*	0.050**	0.114***	0.123***
	(1.777)	(2.407)	(2.780)	(4.281)
Size	0.313***	0.072***	-0.022	-0.010
	(16.559)	(5.562)	(-1.588)	(-0.555)
Lev	0.492***	-0.054	0.187**	0.091
	(4.786)	(-1.294)	(2.465)	(1.558)
Roa	0.461	-0.141	-0.359	-0.175
	(1.269)	(-1.124)	(-1.338)	(-1.011)
Grow	0.007	-0.016	0.024	-0.083***
	(0.147)	(-0.684)	(0.656)	(-2.628)
Tio	0.034	-0.009	0.023	-0.018
	(0.753)	(-0.615)	(0.689)	(-0.913)
Indep	-0.502	-0.275**	1.030***	0.155
	(-1.484)	(-2.117)	(4.122)	(0.866)
Top4	0.034	0.003	0.005	-0.233**
	(0.493)	(0.032)	(0.104)	(-1.966)
Report	0.076	0.036	-0.061	-0.434***
	(0.725)	(1.028)	(-0.789)	(-9.059)
Gdp	0.013*	-0.005	0.009	-0.001
	(1.786)	(-1.597)	(1.597)	(-0.287)
Edu	-0.053***	-0.001	-0.011	-0.004
	(-3.457)	(-0.206)	(-0.983)	(-0.444)
Constant	-7.125***	-1.410***	-0.117	0.390
	(-15.278)	(-5.019)	(-0.341)	(1.005)
Year Fixed Effect	Yes	Yes	Yes	Yes
Firm Fixed Effect	Yes	Yes	Yes	Yes
Observations	1,613	1,613	1,613	1,613
R^2	0.262	0.230	0.040	0.089

*Notes: The t-test results are shown in parentheses, and *, **, *** indicate significance at 0.1, 0.05, and 0.01 levels. Columns (1) and (3) are the results of large-scale firms, while Columns (2) and (4) are the results of small-scale firms.*

Table 16. Heterogeneity test of property rights.

	(1)	(2)	(3)	(4)
VARIABLES	***EQ***	***EQ***	***SQ***	***SQ***

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Itc_s	-0.165***	-0.298***	-0.069**	-0.117*
	(-5.304)	(-2.933)	(-2.241)	(-1.652)
Age	0.082***	-0.006	0.142***	0.095**
	(2.848)	(-0.088)	(4.971)	(2.120)
Size	0.197***	0.176***	-0.008	-0.007
	(19.270)	(10.517)	(-0.763)	(-0.607)
Lev	-0.031	0.389***	0.142**	0.191**
	(-0.547)	(3.216)	(2.508)	(2.257)
Roa	-0.204	0.227	-0.195	-0.340
	(-1.194)	(0.517)	(-1.149)	(-1.110)
Grow	0.039	-0.079	-0.053*	0.053
	(1.382)	(-1.222)	(-1.878)	(1.174)
Tio	-0.006	0.100	-0.001	0.017
	(-0.338)	(1.306)	(-0.039)	(0.316)
Indep	-0.031	-0.983**	0.533***	0.573**
	(-0.177)	(-2.374)	(3.101)	(1.981)
Top4	0.474***	0.027	-0.116	0.024
	(5.870)	(0.351)	(-1.443)	(0.456)
Report	0.011	0.097	-0.548***	0.182**
	(0.226)	(0.854)	(-10.991)	(2.309)
Gdp	0.001	-0.008	-0.000	0.007
	(0.339)	(-0.821)	(-0.074)	(0.961)
Edu	0.003	-0.046***	0.015*	-0.033***
	(0.370)	(-2.589)	(1.780)	(-2.601)
Constant	-4.282***	-3.255***	0.194	-0.390
	(-18.569)	(-7.355)	(0.845)	(-1.263)
Year Fixed Effect	Yes	Yes	Yes	Yes
Firm Fixed Effect	Yes	Yes	Yes	Yes
Observations	2,029	1,197	2,029	1,197
R^2	0.254	0.185	0.101	0.036

*Notes: The t-test results are shown in parentheses, and *, **, *** indicate significance at 0.1, 0.05, and 0.01 levels. Columns (1) and (3) are the results of non-state-owned enterprises, while Columns (2) and (4) are the results of state-owned enterprises.*

Table 17. Results of upstream and downstream differences.

	(1)	**(2)**	**(3)**	**(4)**
VARIABLES	***EQ***	***EQ***	***SQ***	***SQ***
Itc_s	-0.218***	-0.139**	-0.057*	-0.105*
	(-5.184)	(-2.126)	(-1.740)	(-1.795)
Age	0.017	0.141***	0.090***	0.182***
	(0.480)	(2.747)	(3.211)	(3.962)
Size	0.168***	0.227***	0.007	-0.023*
	(14.439)	(14.679)	(0.724)	(-1.675)
Lev	0.269***	-0.100	0.099*	0.221**
	(3.930)	(-0.987)	(1.862)	(2.429)
Roa	0.115	-0.264	-0.119	-0.592**
	(0.521)	(-0.804)	(-0.693)	(-2.008)
Grow	-0.004	-0.007	-0.013	-0.022
	(-0.107)	(-0.150)	(-0.445)	(-0.503)
Tio	0.031	-0.034	-0.012	0.020
	(1.160)	(-0.917)	(-0.585)	(0.593)
Indep	-0.322	-0.149	0.676***	0.193
	(-1.478)	(-0.449)	(3.979)	(0.649)
Top4	-0.032	0.434***	0.025	-0.105
	(-0.534)	(4.694)	(0.537)	(-1.270)
Report	0.149**	-0.028	-0.183***	-0.400***
	(2.210)	(-0.347)	(-3.484)	(-5.444)
Gdp	-0.004	0.009	-0.004	0.018***
	(-0.789)	(1.231)	(-1.041)	(2.681)
Edu	-0.012	-0.029*	0.002	-0.018
	(-1.131)	(-1.901)	(0.204)	(-1.324)

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Constant	-3.531***	-4.962***	-0.325	0.296
	(-13.091)	(-13.189)	(-1.548)	(0.875)
Year Fixed Effect	Yes	Yes	Yes	Yes
Firm Fixed Effect	Yes	Yes	Yes	Yes
Observations	1,996	1,230	1,996	1,230
R^2	0.236	0.271	0.043	0.078

*Notes: The t-test results are shown in parentheses, and *, **, *** indicate significance at 0.1, 0.05, and 0.01 levels. Columns (1) and (3) are the results of customer group firms, while Columns (2) and (4) are the results of supply chain group firms.*

Table 17 presents the results of upstream and downstream differences. The data in the table show that SITC in the customer group has a more significant effect on corporate environmental violations (β=-0.218, p<0.01) and social violations (β=-0.057, p<0.10) than the supply chain group sample. It implies that in the process of SITC, enhancing information sharing between supply chains and promoting the formation of stable relationships in supply chains (Chu *et al.*, 2019), customers more effectively exert the monitoring governance effect on suppliers (Dhaliwal *et al.*, 2016), which reduces corporate violations.

6. Conclusion and Discussion

6.1. *Conclusions*

We conducted a series of tests focusing on SITC and corporate violations. The main results show that SITC inhibits corporate violations, complementing the impact of information technology on corporate E&S strategy from a supply chain perspective (Kuhn & Mansour, 2014; Bernard *et al.*, 2019). Because SITC improves the efficiency of upstream and downstream monitoring and technology transfer and alleviates information asymmetry within the supply chain (Chen *et al.*, 2020), ultimately reducing corporate violations. We used Heckman's two-stage modeling and propensity score matching to address selection bias, and the instrumental variable method to address omitted-variable bias. Besides the endogeneity test, we also applied other robustness tests for the conclusions, including alternative measures of dependent and independent variables, excluding Internet interference, and increasing the sample size.

Furthermore, we tested the mechanisms and delineated the potential impacts across different stakeholders. First, SITC inhibits corporate violations through the external monitoring mechanism (Cabral, 2012; Hollenbeck, 2018) and knowledge spillover mechanism (Kuhn & Mansour, 2014; Goldfarb & Tucker, 2019). Second, SITC has a more substantial impact on corporate violations in higher supply chain concentration because it enhances information sharing across supply chains (Chu *et al.*, 2019). Third, the impact of SITC on violations of corporations lacking government regulation is more significant because stakeholders pay less attention to them, and SITC plays a complementary role (Jia *et al.*, 2019). Then, SITC has a greater impact on large-scale corporations because they have a broader range of stakeholders and greater oversight (Drempetic *et al.*, 2020). Finally, we examined differences between upstream and downstream and confirmed that customers more effectively exert the governance effect of monitoring (Dhaliwal *et al.*, 2016), reducing corporate violations.

6.2. *Implications*

This study provides insights into corporate and government practices. Corporations must fully integrate their advantages and external markets to realize sustainable development. The government can formulate targeted policies to accelerate the digitalization of corporations and promote high-quality economic growth.

Firstly, corporations should strengthen collaboration with other corporations in the supply chain. IT change in the supply chain can encourage corporations to break down "digital silos" and reshape their competitive advantages. Therefore, corporations should construct a learning organization and learn from customers and suppliers the knowledge and experience in information technology and E&S concepts. On this basis, corporations can establish deeper cooperative relationships with partners through property rights or contractual links to broaden the diffusion channels and enhance diffusion effects.

Secondly, the government should focus on guiding collaboration among corporations in the supply chain. IT changes in the supply chain can help corporations break through the plight of "data silos," so the government needs to optimize policies around demand to break down the "information silos" between links in the supply chain. For example, it should promote information sharing between upstream and downstream corporations and encourage customers to transmit market demand information to suppliers through new-generation information technology to promote synergistic development. Moreover, it enables advantageous corporations to establish supply chain alliances to stabilize the cooperative relationship in the supply chain.

6.3. *Limitations and future research*

This study has limitations that need further exploration in the future. The limitations include (1) Although the records can objectively reflect corporate violations, there are still violations that regulators have not detected but have occurred. Under the current conditions, our research does not include these data. (2) Incomplete access to the sample companies' supply chain information. Because most of the upstream and downstream companies of the sample are unlisted companies and have no publicly disclosed financial reports, it is hard to obtain more information about the supply chain. This approach may not accurately represent the broader population in this study, mainly because non-listed firms are excluded due to data accessibility issues and could exhibit different dynamics in terms of IT change.

Moreover, we present a vision for future research: exploring the influencing factors and economic consequences of

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corporate digital responsibility. With industries relying increasingly on next-generation technologies and the evolving legal and regulatory environment, there is a need to explore the possible ethical and social implications of these technologies (Lobschat *et al.*). For example, artificial intelligence is having a considerable impact on the job market, while algorithms based on big data may jeopardize the welfare of consumers.

Acknowledgement

We are also grateful for the comments and criticisms of the journal's reviewers and our colleagues.

Funding

This research was funded by the National Social Science Fund project of China (24BGL175), the Zhejiang Philosophy and Social Sciences Planning Project (25SSHZ041YB) and the Ningbo Philosophy and Social Planning Project (G2025-3-04).

Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Data Availability Statement

Data relevant to the studies in this paper are available upon reasonable request.

Author Contributions Statement

Fangzhou Yao and Rongcheng Zhu wrote the main manuscript text and Yanbin Liu prepared tables 1-15. All authors reviewed the manuscript

Ethical Approval

Not applicable.

Consent to Participate

Not applicable.

Consent to Publish

Not applicable.

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Appendix A: Variable description

Table A Definition of variables

Type	Variable	Code	Measurement
Dependent variable	Environmental violation	EQ	We combine the crawler and manual method to obtain the number of environmental supervision records on the IPE website, the original value plus one, and the natural logarithm
	Social violation	SQ	We select events related to social violations from the litigation arbitration database, add 1 to the original value, and take the natural logarithm
Independent variable	SITC	Itc_s	Intercepted the MD&A part for text analysis to obtain the proportion of IT change characteristic words in the reports and match them by customers/suppliers.
Moderator variable	Supply chain concentration	Supply	We use top 5 customer and supplier concentration.
Control variable	Firm age	Age	Age of firm plus one to take the logarithm
	Asset size	Size	Natural logarithm of assets
	Gearing ratio	Lev	Ratio of liabilities to assets
	Return on asset	Roa	Ratio of net profit to assets
	Growth	Grow	Revenue growth rate
	Duality	Tio	If the board of directors and senior management concurrently assign a value of 1, otherwise0
	Independent directors	Indep	Independent directors as a percentage of board members
	The Four Great Audits	Top4	If the audit is big four is 1, otherwise it is 0
	Audit opinions	Report	1 for unqualified opinion, 0 otherwise
	City economic	Gdp	Logarithms of GDP per capita of each city in the current year
	Urban education	Edu	Logarithmic number of universities in each city in that year
	Individual effect	Firm	Fixed effects controls firm variable
	Year effect	Year	Fixed effects controls year variable

Appendix B: Textual analysis

Considering that the text analysis method can accurately measure continuous data and has recently been widely used and recognized in information technology (Yang, 2022; Liu *et al.*, 2023), we finally chose this method to measure IT change indicators. Text analysis mainly includes three parts: constructing a lexicon of IT change, text analysis of financial reports, and generating IT change indicators (Hoberg & Maksimovic, 2015; Buehlmaier & Whited, 2018). Next, we explain the specific steps and details of the measurement.

Building lexicon

The first step is to construct a lexicon of IT change. The key to the text analysis method is to construct a suitable lexicon, which will affect the accuracy of the indicators. Referring to Yang (2022) and Liu *et al.* (2023), we classify IT into five categories: internet, artificial intelligence, big data, cloud computing, and blockchain, then respectively summarize and organize keywords. On this basis, we expanded the thesaurus of the characteristics by reading the national-level digital-related policy documents and government work reports released by the Chinese government. Then, we used a panel of three experts from recently published high-level papers in IT to evaluate this feature thesaurus to finalize the structured feature words, as shown in **Table B**.

Word segmentation

The second step is to analyze the text of the reports. Referring to Yang (2022) and Liu *et al.* (2023), we obtain the financial reports from Sina Finance and Snowball.com through R programming and extract the Management Discussion and Analysis (MD&A) section, which includes the company's development strategies and business plans, which reflect the extent of corporate IT change (Hoberg & Maksimovic; 2015; Buehlmaier & Whited, 2018). Next, we expanded the 145 structured feature words from step one into the "jieba" Chinese lexicon of the Python software package and performed lexicographic processing on the text content. The IT changes are 107 feature words, including four categories.

Construction method

The third step is the construction of indicators of IT change. Considering the difference in the length of the MD&A, we use the indicator after dividing the word frequency of the keywords by the report word number. In the robustness section, we refer to Steelman *et al.* (2019) and Braxton & Taska (2023), which use the difference to measure IT change, where $\Delta IT_{i,t} = IT_{i,t} - IT_{i,t-1}$.

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Table B Structural feature words of IT change

Panel A: Analysis of the Relevant Concepts of IT Change			
Category	**Internet technology**	**Digital technology**	**IT change**
Internet	√	√	
Artificial intelligence		√	√
Big data		√	√
Cloud computing		√	√
Blockchain		√	√

Panel B: Characteristic words corresponding to different technology categories	
Category	Structured feature word
Internet	Internet, Mobile Internet, Industrial Internet, Internet solutions, Internet technology, Internet thinking, Internet action, Internet business, Internet mobile, Internet applications, Internet marketing, Internet strategy, Internet platform, Internet model, Internet business model, Internet Ecology, E-commerce, Internet, Internet +, Online and offline, Online to offline, O2O, B2B, C2C, B2C, C2B, Networking, Internet medical care, Mobile payment, Third-party payment, NFC payment, Network connection, Internet finance, Digital finance
Artificial intelligence	Artificial intelligence, Business intelligence, Image understanding, Decision assistance systems, Intelligent data analysis, Intelligent robots, Machine learning, Deep learning, Semantic search, Face recognition, Speech recognition, Authentication, Autonomous driving, Natural language processing, Intelligence wear, Smart agriculture, Intelligent transportation, Intelligent medical care, Intelligent customer service, Smart home, Smart investment, Smart travel, Smart environmental protection, Smart grid, Intelligent marketing, Unmanned retail, Smart energy, High-end intelligence, Industrial intelligence, Mobile intelligence, Intelligent control,Intelligent terminal, Intelligent mobile, Intelligent management, Intelligent factory, Intelligent logistics, Intelligent manufacturing, Intelligent warehousing, Intelligent technology, Intelligent equipment, Intelligent production, Intelligent network, Intelligent system, Intelligent, Intelligent fault diagnosis
Big data	Big data, Data mining, Text mining, Data visualization, Heterogeneous data, Credit reporting, Augmented reality, Mixed reality, Virtual reality, Virtual manufacturing, Data management, Data network, Data platform, Data center, Data science, Digital control, Digital technology, Digital communication, Digital network, Digital intelligence, Digital terminal, Digital marketing, Digitalization
Cloud computing	Cloud computing, Stream computing, Graph computing, Memory computing, Multi-party security computing, Brain-like computing, Green computing, Cognitive computing, Converged architecture, Billion-level concurrency, EB-level storage, Internet of things, Information physics systems, Cloud IT, Cloud ecology, Cloud services, Cloud platforms, Industrial clouds
Blockchain	Blockchain, Distributed computing, Digital currency, Cryptocurrency, Differential privacy technology, Smart contract, Decentralization, Ethereum, Non-homogenization, Tokens, Timestamps, Hash values, Hash rates, Distributed ledger, Distributed network, Superbook, Public chain, Private chain, Alliance chain, Cross-chain technology

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