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Does digitization drive corporate social responsibility?

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ABSTRACT

This study investigates the effect of firm-level digitization on corporate social responsibility (CSR) performance. Using a sample of Chinese A-share listed companies from 2010 to 2020 and a textual data mining approach, we find that digitization is positively associated with CSR performance with multiple tests suggesting that this relationship is causal. The study also finds that firm-level digitization promotes CSR by improving innovation inputs and outputs, stimulating innovation, and improving innovation capacity. The findings are more prominent for firms with lower financing constraints, larger sizes, and higher asset cash recovery rates.

1. Introduction

The digital economy has developed rapidly and is deeply integrated with the real economy as a new driver of economic growth. With the explosive growth of the digital economy, research on digitization at the firm level has increasingly become a focus of academic attention (Ravichandran & Liu, 2011). Nevertheless, firm-level digitization still seems to be a black box with multiple mysteries to be solved. In practice, phenomena arise such as "not being able to change" due to weak digital transformation capabilities, "not wanting to change" due to high digital transformation costs, and "not daring to change" due to the extended digital transformation "pain period" (China Information Center, June 2020). In the process of jump-starting the development of the digital economy, and the growing atmosphere of digital transformation, China has tasted the digital dividend, prompting numerous companies to initiate digital transformation (Liu et al., 2021).

Firm-level digital transformation refers to the transition from an industrial management model to a digital management model. By introducing digital technologies into the existing management structure, companies promote disruptive innovations into previously existing management paradigms and systems (Einav & Levin, 2014; Frynas et al., 2018), with extensive impact. Reis et al. (2018) define digital transformation as an organization's use of new digital information technologies to achieve major business changes that impact the flow of users' lives. Hess et al. (2016) assert that digital transformation involves the changes that digital technology brings to a company's business model that lead to alterations in product or organizational structures or process automation. Schallmo et al. (2017) and Verhoef et al. (2021) argue that digital transformation requires the collection of data using digital technologies, analyses, and conversion into actionable information that can be referenced for decision-making and new, data-informed business models to advance performance improvement and expanded operations. In addition, digital transformation is shown to improve corporate

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innovation (Svahn et al., 2017; Appio, Frattini, Petruzzelli, & Neirotti, 2021), increase corporate financial performance (Rosamartina et al., 2022), improve decision-making efficiency (Bharadwaj et al., 2013), and refine operational efficacy (Kraus et al., 2021).

A considerable body of literature focuses on the internal impact of digital transformation on firms; however, a lack of attention to the environmental and social spillover effects of digital transformation in firms remains. As a paradigm shift in development based on technological advances, digital transformation can lead to improved economic benefits for companies as well as generating corresponding ecological and social benefits through changes in corporate behavior. That is to say, enterprises intentionally or unintentionally improve their corporate social responsibility (CSR) performance. For example, Ceruti et al., 2019 finds that companies are using virtual reality (VR) and augmented reality (AR) technologies to better train employees, and Wang et al., 2020 find that companies are using big data to forecast and map market demand, allowing them to better focus on consumers' real needs. In addition, some enterprises are employing digital technology for energy management strategies to increase resource utilization and save energy, reducing carbon dioxide (CO_2) emissions (Mondejar et al., 2021).

In contrast, the use of digital technologies in combination with the agglomeration of big data by businesses could make enterprises highly capital-intensive, which may lead to higher energy consumption if not carefully managed (Salahuddin & Alam, 2015). Companies' digital transformation could also generate employment reductions (Carolan, 2020; Frey & Osborne, 2017), which can have negative effects on CSR. Therefore, despite the growing number of companies undertaking digital transformation to better fulfill social responsibilities, the existing literature does not offer a consistent conclusion regarding the effects of digitization on CSR performance. Furthermore, accurately measuring enterprises' degree of digital transformation and determining the mechanisms by which digital transformation affects CSR are among the difficulties faced in advancing the related research.

This study constructs a relatively complete digital lexicon using semantic representations of Chinese national policies related to the digital economy and machine learning text analysis to construct a comprehensive indicator of Chinese listed enterprises' degree of digitization to examine the impact of the degree of digitization of microenterprises on CSR and its mechanisms. The empirical study finds that increased digitization significantly contributes to CSR performance. Mechanistic tests suggest that digitization primarily contributes to CSR performance by increasing firms' level of research and development (R&D) and innovation. Heterogeneity analysis demonstrates that the effect of digitization on promoting corporate specialization is more significant for large firms and those with low financing constraints versus high asset cash recovery rates. These findings support the perspective of "doing good by doing well," by examining whether only well-performing firms can afford CSR investment.

The marginal contributions of our study are as follows. First, we enrich the literature on the non-financial impacts of digitization and CSR impact factors. Second, we theoretically analyze the contribution of digital transformation to CSR performance, examining the impact channels from the perspective of innovative R&D. Generally speaking, companies must invest considerable capital and sunk costs to facilitate digital transformation, while R&D investment and CSR are also budgeted as costs. As all three areas can erode a company's profits, why are companies motivated to invest in them? Our mechanism reveals that digital transformation stimulates innovation, which leads to increased CSR. Digital transformation can be said to require one input and generate multiple benefits. Third, our heterogeneity analysis supports the classical rationale for companies' engaging in CSR — doing good by doing well.

The remainder of this paper is organized as follows. Additional institutional background and hypotheses development are described in Section 2. Section 3 summarizes the data and presents the sample summary. Section 4 reports the main findings, and Section 5 provides additional supportive results. The final section concludes the study.

2. Theoretical analysis and research hypothesis

Regarding strategic CSR decisions, companies' digital transformation can reinforce collectivist tendencies, which can facilitate the motivation to fulfill social responsibilities. The primary reason for this is that digital technologies enable individuals to come together and act together, reducing the cost of collective participation and enabling the organization of collective action (Young et al., 2019). When digital transformation penetrates the dynamic environment of organizational and stakeholder management, features such as the openness and inclusiveness of digital technologies enable stakeholders' participation in enterprises' decision-making processes (Adams & Frost, 2006). The subsequent adoption of digital participation mechanisms and proactive construction of digital microsocieties or digital communities based on collectivism emphasizes community-based social order and advancing overall welfare (Hörisch et al., 2014), which can reinforce companies' social responsibility orientation (Vollero et al., 2020).

Regarding the nature of CSR, enterprises are a collection of various stakeholders. By digitally capturing and analyzing relevant data to identify the value demands of relevant stakeholders, enterprises can leverage internal and external resources to target and meet the needs of stakeholders. Digital technology is used to gain information through enhanced communication capabilities, allowing companies to have conversations with and solicit feedback from consumers as valued stakeholders (Yeow et al., 2018), which enables companies to meet consumers' needs more accurately. Energy management strategies based on digital technologies can streamline resource use, save energy, and reduce CO2 emissions (Mondejar et al., 2021). Digital technologies can also ensure lower scrap rates, high saturation of manufacturing facilities, low waste, and excellent energy efficiency (Stock & Seliger, 2016), which can enable companies to address stakeholders' concerns, such as the environment and society. The use of technologies such as VR and AR for employee training (Ceruti et al., 2019) enhances employees' skills and work experiences. With the advantages of digitalization, companies can expediently respond to multiple stakeholder value propositions, including social stakeholders who are often excluded from traditional business models, in a process of value co-creation that enables companies to collaboratively develop multiple values with stakeholders.

Therefore, this study proposes the following research hypothesis:

Table 1
The definition of variables.

Variable type	Variable name	Notation	Definition
Dependent variable	Corporate social responsibility	*Lncsr*	Ln(total CSR score)
Explanatory variable	Degree of digital transformation of the enterprise	*Digital*	See details in the text
Control variables	Size of the enterprise	*Size*	Natural logarithm of total assets
	Leverage	*Leverage*	Leverage = liabilities/assets
	Liquidity	*Liquidity*	Liquidity ratio = current assets/current liabilities
	Return on Equity	*ROE*	ROE = Net income/average net assets
	Revenue growth rate	*Growth*	Revenue growth rate
	Firm Age	*Age*	Age = Current year - year of IPO
	The shareholding ratio of the top shareholder	*Top1*	The shareholding ratio of the top shareholder
	Board size	*Board*	Number of the board of directors
	The ratio of independent directors	*Indep*	Independent directors/board of directors
	Duality	*Dual*	If the chairman and general manager are the same, equals 1, otherwise 0
	Nature of Property Right	*SOE*	If state-owned enterprise, equals 1, otherwise 0

Table 2
Descriptive statistics.

Variable	Obs	Mean	SD	P25	Median	P75
Lncsr	13797	3.074	0.653	2.872	3.118	3.325
Digital	13797	0.104	0.168	0.013	0.041	0.108
Size	13797	22.353	1.285	21.433	22.184	23.079
Leverage	13797	0.430	0.201	0.269	0.424	0.582
Liquidity	13797	2.366	2.302	1.173	1.633	2.587
ROE	13797	0.080	0.080	0.038	0.076	0.120
Growth	13797	0.352	0.847	−0.014	0.141	0.403
Age	13797	17.671	5.739	13.500	17.580	21.580
Top1	13797	0.350	0.147	0.234	0.331	0.450
Board	13797	8.604	1.688	7.000	9.000	9.000
Indep	13797	0.376	0.054	0.333	0.364	0.429
Dual	13797	1.715	0.451	1.000	2.000	2.000
SOE	13797	0.324	0.468	0.000	0.000	1.000

H1. When other conditions remain constant, firm-level digital transformation can improve CSR performance.

Enterprises' R&D activities are an endogenous driving force of CSR. Digital transformation stimulates the vitality of corporate innovation and improves the level of innovation, which encourages CSR activities. The promotional effect of digitalization on the level of corporate R&D innovation is primarily reflected in three aspects. (1) Information channels. Corporate digitalization can promote broad communication of internal and external information, enhance the integration and sharing of external information, and subsequently improve enterprises' R&D innovation capabilities (Subramaniam & Youndt, 2005). Digital transformation also enables companies to expediently identify current market demands and consumers' expectations and elicit customers' opinions regarding product improvement. Companies can also use digital technology to assess product sales and related customer needs to strategically adjust the direction of innovation promptly (Kroh et al., 2018). (2) Resource channels. A necessary condition for innovation is continuous investment in innovation resources. Companies are more inclined to invest in innovation resources to gain an edge over the competition and achieve corporate goals (Wen et al., 2022). Digital transformation also drives green innovation by increasing investment in innovation resources and reducing the cost of debt (Liu, Liu et al., 2023). Firms' use of digital technology can reduce transaction, operational, agency, and innovation costs, motivating firms to invest more in R&D (Liu, Li et al., 2023). (3) Human resource channel. Digital transformation will replace some jobs with low labor skills with digital equipment; however, it implies the use of new technologies, which leads to high demand for skilled personnel (Bresnahan et al., 2002; Schwarzmüller et al., 2018). The introduction of highly skilled people enhances employees' ability to accept and apply new knowledge, facilitating increased innovation (Ma et al., 2019). Companies with a highly skilled workforce with a higher and broader knowledge base are more capable of generating new ideas and have a greater capacity for R&D innovation.

R&D is considered to be a form of investment that leads to more knowledge and capabilities, which also leads to innovation in CSR products and processes and improved CSR performance. R&D activities may improve processes and make them more efficient, which can also reduce the amount of energy consumed, lowering costs and pollution emissions, and ultimately improving CSR performance (Padgett & Galan, 2010). Fu et al. (2020) argue that the two domains of R&D and CSR share relevant knowledge that establishes synergies, such as information regarding stakeholders and their needs. Yu et al. (2020), find that an increase in R&D spending within a certain range significantly contributes to improving product quality, increases the efficiency of production processes, and ensures production safety, improving CSR performance, but has minimal impact on corporate philanthropic behavior. McWilliams & Siegel (2000) argue that R&D and CSR activities are related to product and process innovation and CSR is positively related to R&D. Mishra (2017) demonstrates that companies are more willing to improve CSR performance to gain a reputation following R&D success. Rising

Table 3
Correlation analysis.

	Lncsr	Digital	Size	Lev	Liq	Roe	Growth	Age	Top1	Board	Indep	Dual	SOE
Lncsr	1												
Digital	0.10*	1											
Size	0.37*	0.03	1										
Lev	0.12*	−0.03	0.58*	1									
Liq	−0.16*	0.11*	−0.44*	−0.70*	1								
ROE	0.03	0.03	0.10*	−0.10*	0.08*	1							
Growth	−0.08*	0.13*	0.05*	0.14*	0.06*	0.06*	1						
Age	0.07*	0.02	0.13*	0.08*	−0.10*	−0.01	0.09*	1					
Top1	0.16*	−0.01	0.25*	0.11*	−0.08*	0.10*	−0.02	−0.19*	1				
Board	0.15*	−0.01	0.18*	0.09*	−0.16*	−0.04*	−0.11*	0.01	0	1			
Indep	−0.04*	0.08*	0.05*	0.01	−0.01	−0.01	0.07*	−0.06*	0.10*	−0.40*	1		
Dual	0.07*	0.01	0.11*	0.09*	−0.09*	−0.03*	−0.03	0.03	0.07*	0.13*	−0.06*	1	
SOE	0.14*	−0.01	0.34*	0.22*	−0.14*	−0.10*	0.01	0.05*	0.30*	0.25*	−0.04*	0.23*	1

* denote significance at 5%.

Table 4
Benchmark regressions on the effect of digital transformation on CSR performance.

Variables	*Lncsr*	*Lncsr*	*Lncsr*	*Lncsr*	*Lncsr*
	(1)	(2)	(3)	(4)	(5)
Digital	0.094***	0.093***	0.090***	0.090***	0.092***
	(0.034)	(0.034)	(0.034)	(0.035)	(0.035)
Size	0.132***	0.121***	0.121***	0.121***	0.121***
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
Leverage	−0.644***	−0.656***	−0.658***	−0.653***	−0.662***
	(0.055)	(0.056)	(0.056)	(0.054)	(0.054)
Liquidity	0.002	0.002	0.002	0.001	0.001
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Roe	4.379***	4.412***	4.395***	4.368***	4.371***
	(0.120)	(0.121)	(0.121)	(0.119)	(0.121)
Growth	−0.006	−0.006	−0.007	−0.006	−0.005
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
Age	0.002	0.001	0.001	0.001	0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Top1		0.010	0.013	0.021	0.022
		(0.047)	(0.047)	(0.046)	(0.046)
Board		0.007	0.007	0.010*	0.010*
		(0.005)	(0.005)	(0.005)	(0.005)
Indep		0.121	0.120	0.145	0.156
		(0.147)	(0.148)	(0.144)	(0.145)
Dual		−0.003	−0.002	0.002	0.002
		(0.013)	(0.013)	(0.013)	(0.013)
SOE		0.068***	0.067***	0.069***	0.070***
		(0.019)	(0.019)	(0.018)	(0.018)
Pop					−0.141*
					(0.077)
GDP					−0.070
					(0.193)
_cons	0.170	0.278*	0.139	0.267*	2.168
	(0.140)	(0.160)	(0.165)	(0.156)	(1.439)
Industry FE	Yes	Yes	No	Yes	Yes
Year FE	Yes	Yes	No	Yes	Yes
Province FE	No	No	No	Yes	Yes
Industry × Year FE	No	No	Yes	No	No
Observations	13797	13797	13797	13797	13797
Adjusted R^2	0.455	0.457	0.466	0.466	0.458

*, **, and *** denote two-tailed significance at 10%, 5%, and 1%, respectively.

levels of R&D innovation promote innovation in CSR-related products and processes, which can advance companies' production of more socially responsible products, enhancing enterprises' reputations and image (Delgado-Verde et al., 2021), making them more inclined to fulfill CSR to maintain and sustain this image. To differentiate products, companies that spend more on R&D will also invest in CSR activities (McWilliams & Siegel, 2001; Padgett & Galan, 2010).

Thus, we propose hypothesis 2 as follows:

H2. Digitalization enhances CSR performance by increasing the level of corporate R&D innovation.

Digital transformation, R&D innovation, and CSR require considerable resources. Based on the constraints of corporate resources, digital transformation incurs certain financial risk. If the transformation is unsuccessful, it will lead to resource waste and could generate financial challenges that directly affect business operations and harm stakeholders' interests. Small-scale enterprises are more risk-averse than large-scale companies and have fewer resources, meaning that it is difficult for small-scale enterprises to balance digitalization and CSR. Adequate cash flow and the ability to raise capital will naturally affect firms' ability to properly fulfill CSR. If there is a high level of financing constraint, companies' exogenous financing capabilities will be limited, overall cash flow will be reduced, leading to a lack sufficient funds to support CSR. In contrast, if an enterprise has strong financing ability, the ability of assets generating cash flow will be high, leading to a higher inclination to fulfill social responsibility, advancing the performance of CSR.

Therefore, this study expects that the relationship between the degree of corporate digital transformation and CSR may also be influenced by financing constraints and the ability of assets to generate cash flow. Hypothesis 3 is therefore proposed as follows:

H3. The promotion of CSR through digitalization is primarily concentrated among enterprises that are doing well, referring to low financing constraints, the ability of assets to generate cash flow, and larger size.

Table 5
Regression of the impact of digital transformation on the CSR sub-dimensions.

Variables	Ln(supplier, customer, and consumer responsibility)	Ln(employee responsibility)	Ln(environmental responsibility)	Ln(social responsibility)	Ln(shareholder responsibility)
	(1)	(2)	(3)	(4)	(5)
Digital	0.060**	0.059**	0.051**	0.044*	0.008
	(0.029)	(0.028)	(0.026)	(0.023)	(0.007)
Size	0.065***	0.077***	0.078***	0.027***	0.018***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.002)
Lev	−0.078**	−0.087**	−0.077*	−0.131***	−0.209***
	(0.035)	(0.040)	(0.040)	(0.038)	(0.012)
Liq	−0.000	−0.003	−0.004	−0.002	0.001
	(0.002)	(0.003)	(0.003)	(0.002)	(0.001)
Roe	0.417***	0.265***	0.246***	0.775***	1.327***
	(0.048)	(0.060)	(0.060)	(0.064)	(0.034)
Growth	0.004	−0.010**	−0.011**	0.006	−0.002
	(0.005)	(0.005)	(0.005)	(0.004)	(0.001)
Age	−0.001	0.000	0.000	0.003***	−0.001***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)
Top1	−0.093***	−0.082**	−0.079*	0.013	0.012
	(0.035)	(0.041)	(0.040)	(0.029)	(0.009)
Board	0.001	0.006	0.006	0.001	−0.000
	(0.004)	(0.004)	(0.004)	(0.003)	(0.001)
Indep	0.116	0.203*	0.182	0.111	−0.038
	(0.098)	(0.120)	(0.120)	(0.080)	(0.027)
Dual	−0.004	−0.009	−0.008	0.017**	−0.002
	(0.010)	(0.011)	(0.011)	(0.008)	(0.003)
SOE	0.061***	0.062***	0.064***	−0.003	−0.004
	(0.014)	(0.016)	(0.016)	(0.011)	(0.003)
_cons	−0.685***	−1.379***	−1.395***	0.219**	0.882***
	(0.106)	(0.117)	(0.117)	(0.097)	(0.033)
Industry FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Observations	13797	13797	13797	13338	13639
Adjusted R^2	0.224	0.202	0.228	0.178	0.555

*, **, and *** denote two-tailed significance at 10%, 5%, and 1%, respectively.

3. Research design

3.1. Sample selection and data source

In this study, we use the data of all listed Chinese A-share companies from 2010 to 2020 as the initial research sample, processing it by removing financial, real estate, and ST companies, and those with missing research variables and applying a two-sided 1% winsorizing process to avoid the influence of outliers on the empirical results. Companies' financial data are obtained from the China Stock Market & Accounting Research database, and CSR data are obtained from Hexun.com (http://stock.hexun.com). The key variable (the degree of digital transformation) is determined using the statistical aggregation of keywords in companies' annual reports.

3.2. Models and variable definitions

To examine the impact of the degree of digital transformation on CSR in H1, we construct the following model:

$$Lncsr_{i,t} = \alpha_0 + \alpha_1 Digital_{i,t} + \sum \alpha_j Controls_{j,i,t} + Industry\ FEs + Year\ FEs + \varepsilon_{i,t} \quad (1)$$

where the dependent variable ($Lncsr_{i,t}$) represents the natural logarithm of the total CSR performance score for firm i in year t. The key explanatory variable ($Digital_{i,t}$) represents the level of digitalization of firm i in year t and calculated based on the proportion of intangible assets related to digital transformation to total intangible assets, which is recorded in the year-end intangible asset line items disclosed in the notes of enterprises' financial reports. Specifically, when the intangible asset line item contains keywords related to digital transformation techniques, such as "software," "network," "app," "management system," "intelligent platform," and associated patents, the line item is defined as "digital technology intangible assets." We then calculate the proportion of enterprises' total intangible assets as a proxy variable for the degree of digital transformation. $Controls_{i,t}$ represents a series of control variables. Variable names, notations, and definitions are presented in Table 1. This study also controls for year and industry fixed effects, and all regression equations apply robust standard errors clustered by firm.

Table 6
Endogeneity test.

Variables	IV method		One-period lag	Heckman two-stage regression	
	Digital	Lncsr	Lncsr	ifDigital	Lncsr
	(1)	(2)	(3)	(4)	(5)
meaniv	0.992***				
	(0.040)				
L.Digital			0.124***		
			(0.038)		
Digital		0.200***			0.092***
		(0.076)			(0.034)
Size	−0.009***	0.123***	0.116***	0.063***	0.084***
	(0.003)	(0.007)	(0.008)	(0.012)	(0.009)
Leverage	0.051***	−0.663***	−0.628***	−0.082	−0.601***
	(0.017)	(0.056)	(0.061)	(0.090)	(0.056)
Liquidity	0.004***	0.001	−0.000	−0.001	0.003
	(0.001)	(0.003)	(0.004)	(0.006)	(0.003)
Roe	0.031	4.409***	4.461***	0.435***	4.307***
	(0.024)	(0.121)	(0.133)	(0.147)	(0.132)
Growth	0.005*	−0.007	−0.004	0.022*	−0.017***
	(0.003)	(0.006)	(0.007)	(0.013)	(0.006)
Age	−0.001	0.001	0.001	−0.003	0.002*
	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)
Top1	0.018	0.008	0.018	0.038	−0.013
	(0.018)	(0.047)	(0.050)	(0.082)	(0.046)
Board	0.001	0.007	0.003	0.032***	−0.008
	(0.002)	(0.005)	(0.006)	(0.009)	(0.006)
Indep	0.022	0.114	0.121	0.562**	−0.133
	(0.047)	(0.147)	(0.158)	(0.253)	(0.152)
Dual	−0.003	−0.002	0.006	−0.031	0.017
	(0.005)	(0.013)	(0.015)	(0.027)	(0.014)
SOE	0.006	0.068***	0.067***	−0.129***	0.138***
	(0.006)	(0.019)	(0.019)	(0.029)	(0.023)
imr					−1.245***
					(0.252)
IPR				0.872***	
				(0.214)	
_cons			0.086	−1.344***	1.238***
			(0.183)	(0.306)	(0.280)
Industry FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Observations	13,797	13,797	10368	17746	13797
Adjusted R^2	n.a.	n.a.	0.468	n.a.	0.457
F value	628.516 [16.38]				

Note: The critical values for the Stock-Yogo weak instrumental variable identification *F*-test at the 10% significance level are shown in square brackets. *, **, and *** denote two-tailed significance at 10%, 5%, and 1%, respectively.

3.3. Descriptive statistics

Table 2 presents the descriptive statistics of the full sample. As previously noted, we winsorize all continuous variables at the 1st and 99th percentiles to avoid the effect of outliers. Table 2 indicates that the mean value of company digitalization (*Digital*) is 0.104, the standard deviation is 0.168, the 25% quantile (P25) is 0.013, and the 75% quantile (P75) is 0.108, revealing considerable difference in listed companies' degree of digitalization. Among the explanatory variables, the mean value of CSR is 3.074, the standard deviation is 0.653, P25 is 2.872, and P75 is 3.325, indicating varying degrees of CSR performance among listed companies.

Table 3 presents a correlation analysis matrix, revealing a significant correlation between digitization and CSR. Finally, CSR correlates with most of the control variables at a 5% significance level, illustrating the rationality of the control variables used in this study.

4. Empirical analysis

4.1. Benchmark regression

Table 4 presents the results of the benchmark regressions on the relationship between digital transformation and CSR performance, using an incremental regression strategy. Column (1) only controls the financial characteristics of companies and year–industry fixed effects, while column (2) introduces the financial and corporate governance characteristics, with year–industry fixed effects. The

Table 7
Robustness tests.

Variables	*Lnrlcsr*	*Lncsr*	*Lncsr*	*Lncsr*
	Alternative measures for CSR	Removing IT-related industries	Excluding the years 2015 and 2020	With *Firm* × *Year FE*
	(1)	(2)	(3)	(4)
Digital	0.237**	0.085**	0.107***	0.092***
	(0.100)	(0.039)	(0.038)	(0.034)
Size	0.101***	0.126***	0.133***	0.127***
	(0.012)	(0.008)	(0.008)	(0.007)
Leverage	−0.260**	−0.686***	−0.672***	−0.644***
	(0.101)	(0.058)	(0.061)	(0.056)
Liquidity	−0.002	0.001	−0.000	0.002
	(0.009)	(0.003)	(0.003)	(0.003)
Roe	−0.055	4.384***	4.202***	4.37***
	(0.102)	(0.126)	(0.138)	(0.121)
Growth	−0.013	−0.008	−0.010	−0.007
	(0.013)	(0.006)	(0.007)	(0.006)
Age	0.004	0.001	0.001	0.002
	(0.003)	(0.001)	(0.001)	(0.001)
Top1	0.239***	−0.004	0.006	0.043
	(0.092)	(0.048)	(0.052)	(0.047)
Board	0.011*	0.006	0.009	0.007*
	(0.007)	(0.005)	(0.006)	(0.004)
Indep	0.056	0.091	0.212	0.008
	(0.210)	(0.152)	(0.161)	(0.013)
Dual	0.005	−0.002	−0.001	0.024
	(0.024)	(0.014)	(0.015)	(0.145)
SOE	−0.005	0.060***	0.069***	0.092***
	(0.031)	(0.019)	(0.021)	(0.034)
_cons	0.944***	0.228	0.000	0.127***
	(0.258)	(0.166)	(0.174)	(0.007)
Industry FE	Yes	Yes	Yes	No
Year FE	Yes	Yes	Yes	No
Firm FE	No	No	No	No
Firm × *Year FE*	No	No	No	Yes
Observations	2242	12918	10861	13793
Adjusted R^2	0.380	0.456	0.435	0.457

*, **, and *** denote two-tailed significance at 10%, 5%, and 1%, respectively.

coefficients of *Digital* are all positive at the 1% significance level, indicating that the higher the degree of digital transformation is, the better the CSR performance will be, which is consistent with H1. Column (3) adds the year × industry fixed effect, and the coefficient of *Digital* is significantly positive at the 1% level. Column (4) introduces the province fixed effect to column (2) calculations, and the *Digital* coefficient is significantly positive at the 1% level. Column (5) controls for provincial GDP and population variables in addition to those used in column (2), and the *Digital* coefficient is significantly positive at the 1% level. These results support our hypotheses.

In terms of economic implications, the results in column (2) indicate that a 1% increase in corporate digitalization would increase CSR performance by 9.3%, representing a rise of about 3% (= 0.093/3.074 × 100%) compared with the mean CSR performance value of 3.074 over the sample period. This suggests that companies' digital transformation contributes to CSR performance, in both the economic and statistical sense.

Table 5 shows the impact of corporate digitalization on the CSR subdimensions. The CSR data obtained from Hexun.com are divided into five dimensions, including supplier, customer, consumer, employee, environmental, social, and shareholder responsibility. The findings in Table 5 confirm that digitalization has a significant positive effect on all CSR subdimensions except for shareholder responsibility.

4.2. Endogeneity test

There are potential endogeneity problems in our previous findings. First, improved digitalization promotes the fulfillment of CSR, while, at the same time, companies with high CSR performance also have higher demand and motivation to promote digital transformation to facilitate improved integration in the market and fulfill CSR. Furthermore, some companies have a high degree of digital transformation, whereas others do not pursue it. A company's decision to conduct digital transformation is influenced by multiple subjective and objective factors; thus, companies that conduct digital transformation are sample selective, which may lead to endogeneity problems. To ensure the reliability of the research findings, we use the following methods to reduce the endogeneity problems.

Instrumental variable method. We use the mean value of the region–industry–year digitalization level as the instrumental variable (*meaniv*), a company's digitalization level highly related to the region–industry level where the company is in the same year. Column (1) in Table 6 shows that the coefficient of the instrumental variable *meaniv* is significantly positive and the *F*-value estimated

Table 8
Mechanism testing A.

Variables	*Lncsr*	*Lncsr*	*Lncsr*	*Lncsr*
	R&D intensity		The ratio of research personnel	
	Low	High	Low	High
	(1)	(2)	(3)	(4)
Digital	0.104**	0.013	0.156***	0.062
	(0.050)	(0.048)	(0.045)	(0.047)
Size	0.130***	0.058***	0.127***	0.110***
	(0.010)	(0.010)	(0.010)	(0.009)
Leverage	−0.683***	−0.344***	−0.817***	−0.498***
	(0.073)	(0.075)	(0.075)	(0.068)
Liquidity	0.000	0.012***	−0.006	0.009**
	(0.004)	(0.005)	(0.006)	(0.004)
Roe	4.339***	4.988***	4.047***	4.916***
	(0.161)	(0.200)	(0.150)	(0.167)
Growth	−0.008	−0.007	−0.000	−0.011
	(0.010)	(0.011)	(0.008)	(0.009)
Age	0.004***	−0.003*	0.001	−0.001
	(0.002)	(0.002)	(0.002)	(0.002)
Top1	0.025	0.009	0.054	−0.046
	(0.061)	(0.060)	(0.064)	(0.057)
Board	0.011	−0.004	0.005	0.008
	(0.007)	(0.007)	(0.007)	(0.007)
Indep	0.284	−0.287	0.012	0.189
	(0.183)	(0.214)	(0.198)	(0.185)
Dual	−0.001	0.009	−0.007	−0.004
	(0.017)	(0.017)	(0.018)	(0.017)
SOE	0.058**	0.073***	0.077***	0.061**
	(0.025)	(0.024)	(0.024)	(0.024)
_cons	−0.077	1.681***	0.326	0.382*
	(0.214)	(0.242)	(0.223)	(0.198)
Industry FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Observations	7550	4250	7108	6674
Adjusted R^2	0.427	0.496	0.446	0.479

*, **, and *** denote two-tailed significance at 10%, 5%, and 1%, respectively.

in the first stage is 628.5, which is higher than the critical value of the Stock–Yogo weak instrumental variable identification *F*-test at a 10% significance level, indicating that there is no weak instrumental variable problem, confirming that the chosen instrumental variable is appropriate. Column (2) shows that the coefficients of *Digital* are all significantly positive, signifying that the hypotheses of this study are robust and reliable.

Regressing using explanatory variables with a one-period lag. The level of digital transformation with a one-period lag may significantly affect a company's emphasis on digital transformation but has no direct impact on its future CSR performance. Column (3) of Table 6 presents the results of the regression using lagged explanatory variables. The coefficient of *L.Digital* is significant at the 1% level, supporting our hypotheses.

Hackman two-stage regression. Based on the previous empirical analysis, we construct a Heckman two-stage test. In the first stage, the dummy variable *ifDigital* is generated equaling 1 if the company has conducted digitalization and 0 otherwise. At this stage, we add internet penetration rate (IPR) as a control variable. The rationale for this is because the IPR will have an impact on local companies' digital transformation but not on CSR. We then replace the dependent variable with *ifDigital* in the regression to determine the probability of companies' digital transformation using the probit model and calculate the inverse Mills ratio (*imr*). In the second stage, we plug the *imr* into the original model as a control variable for regression. The results are presented in column (5) of Table 6. The coefficient of the inverse Mills ratio (*imr*) is significant, indicating a selection bias, and the coefficient of *Digital* is significantly positive, further validating our hypotheses.

4.3. Robustness tests

We apply the following approaches for robustness tests.

Using an alternative dependent variable. Considering the differences in CSR ratings from Hexun Co. and Runling Co. (http://www.rksratings.cn/), we replace the CSR rating data with Runling Co. in the regression and obtain the results in column (1) of Table 7.

Regressing with new samples. Given the industry's unique digitalization and informatization advantages, we exclude the computer, communication, and other electronic equipment manufacturing industry from the sample, presenting the results in column (2) of Table 7.

Excluding abnormal years. In the sample period of this study, two important events may have affected enterprises' digital

Table 9
Mechanism testing B.

Variables	*Lncsr*	*Lncsr*	*Lncsr*	*Lncsr*
	Patent applications per capita		Patent citations per capita	
	Low	High	Low	High
	(1)	(2)	(3)	(4)
Digital	0.124***	0.059	0.133***	0.040
	(0.042)	(0.050)	(0.042)	(0.053)
Size	0.132***	0.109***	0.126***	0.120***
	(0.010)	(0.010)	(0.010)	(0.010)
Leverage	−0.836***	−0.434***	−0.802***	−0.488***
	(0.069)	(0.076)	(0.069)	(0.079)
Liquidity	−0.006	0.011***	−0.003	0.010**
	(0.004)	(0.004)	(0.004)	(0.005)
Roe	4.364***	4.470***	4.044***	4.713***
	(0.152)	(0.177)	(0.154)	(0.178)
Growth	−0.007	−0.006	−0.003	−0.012
	(0.008)	(0.009)	(0.008)	(0.010)
Age	0.002	0.000	0.000	0.001
	(0.002)	(0.002)	(0.002)	(0.002)
Top1	0.019	−0.005	0.017	−0.032
	(0.062)	(0.061)	(0.059)	(0.067)
Board	0.008	0.006	0.007	0.007
	(0.007)	(0.007)	(0.007)	(0.007)
Indep	0.050	0.206	0.111	0.159
	(0.191)	(0.194)	(0.191)	(0.200)
Dual	−0.008	0.003	−0.016	0.017
	(0.017)	(0.018)	(0.016)	(0.020)
SOE	0.065***	0.069***	0.053**	0.083***
	(0.024)	(0.025)	(0.025)	(0.025)
_cons	0.139	0.439**	0.305	0.156
	(0.213)	(0.219)	(0.216)	(0.227)
Industry FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Observations	7170	6627	7053	6744
Adjusted R^2	0.467	0.447	0.432	0.485

*, **, and *** denote two-tailed significance at 10%, 5%, and 1%, respectively.

transformation. One was China's 2015 stock market crash in China, and the other was the global COVID-19 pandemic in 2020. Companies' digital transformation is highly responsive to major negative events, and neglecting such impact may introduce bias into the regression results. Column (3) of Table 7 is obtained after eliminating the time periods of these events.

Omitted variable problem. Considering possible omitted variables, we also apply the year × firm two-way fixed effects, presenting the results in column (4) of Table 7.

The results in Table 7 confirm that the findings of this study pass the above robustness tests.

5. Further analysis

5.1. Mechanism testing: the impact of R&D innovation

The previous analysis suggests that the mechanism by which digital transformation promotes companies' CSR performance is realized through an increased level of R&D innovation. It is expected that if the effect of digitalization on CSR is indeed achieved by increasing the level of R&D and innovation, then this increase should be more beneficial to companies with low R&D and innovation levels, contributing more significantly to CSR performance.

Examining the effect of R&D innovation requires identifying the proxy variables for R&D innovation inputs and outputs. For R&D innovation input, we use the ratio of research personnel and R&D investment as a percentage of business revenue to measure the level of corporate R&D investment. For output, we use the number of patent applications per capita, and the number of patents cited per capita as indicators. The number of patent applications and patent citations per capita can reflect the efficiency of input resources and the capacity of R&D innovation.

We divide the sample into two groups according to whether R&D intensity and the ratio of research personnel are greater than industry and annual medians. The regression results are presented in Table 8, demonstrating that for both R&D intensity and the ratio of research personnel for the low R&D innovation group the coefficients of *Digital* are positive and significant at the 5% level, whereas the *Digital* coefficients for the high R&D innovation group are no longer significant. The coefficients of *Digital* for low groups is 0.104 and 0.156, respectively, which is also significant in an economic sense; thus, the impact of digital transformation on CSR is only evident among companies with low R&D intensity and the ratio of research personnel.

Table 10
Heterogeneity analysis A.

Variables	*Lncsr*	*Lncsr*	*Lncsr*	*Lncsr*
	Financing constraint SA index		Dividend payout ratio	
	Low	High	Low	High
	(1)	(2)	(3)	(4)
Digital	0.145***	0.034	0.100**	0.058
	(0.042)	(0.053)	(0.044)	(0.040)
Size	0.105***	0.151***	0.093***	0.135***
	(0.009)	(0.012)	(0.011)	(0.008)
Leverage	−0.499***	−0.789***	−0.476***	−0.538***
	(0.077)	(0.073)	(0.076)	(0.059)
Liquidity	0.006	−0.001	0.002	0.007
	(0.004)	(0.005)	(0.004)	(0.004)
Roe	4.627***	4.206***	5.387***	2.800***
	(0.173)	(0.160)	(0.158)	(0.115)
Growth	−0.005	−0.006	−0.002	0.000
	(0.009)	(0.008)	(0.011)	(0.006)
Age	0.001	−0.001	0.001	0.001
	(0.002)	(0.003)	(0.002)	(0.001)
Top1	0.006	0.030	−0.053	0.036
	(0.060)	(0.068)	(0.062)	(0.055)
Board	−0.001	0.012*	0.012*	−0.003
	(0.007)	(0.007)	(0.007)	(0.006)
Indep	−0.044	0.279	0.292	−0.034
	(0.198)	(0.202)	(0.197)	(0.163)
Dual	0.012	−0.017	−0.003	−0.012
	(0.018)	(0.020)	(0.018)	(0.016)
SOE	0.066**	0.066***	0.086***	0.053***
	(0.027)	(0.023)	(0.025)	(0.020)
_cons	0.642***	−0.347	0.677***	0.205
	(0.204)	(0.264)	(0.235)	(0.183)
Industry FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Observations	6891	6906	7278	6519
Adjusted R^2	0.474	0.444	0.548	0.326

*, **, and *** denote two-tailed significance at 10%, 5%, and 1%, respectively.

According to the median industry–year number of patent applications per capita, companies are divided into high and low patent applications per capita groups and into high and low patent citations per capita groups. The results in columns (1)–(3) of Table 9 show that the coefficient of *Digital* is significantly positive at the 1% level, indicating that the promotional effect of digitalization on CSR is more significant when the level of R&D output is low or when firms have fewer patent applications and fewer citations per capita, confirming the initial expectations.

Overall, this effect demonstrates that the promotional effect of digital transformation on CSR is achieved by improving companies' level of R&D and innovation.

5.2. Heterogeneity analysis: the impact of financing constraints

As the previous theoretical analysis shows, enterprises' digitalization can improve R&D innovation and promote CSR performance. However, digital transformation, R&D innovation, and CSR performance can be considered corporate investment activities, which is influenced by corporate financing constraints. Therefore, the promotion of digitalization for CSR may also be affected by financing constraints.

This study further investigates whether digitalization has a heterogeneous promotional effect on CSR among companies with different financing constraints. Specifically, when the level of financing constraint is low, the promotional effect of digitalization on CSR should be higher. To examine this assumption, this study uses two indicators to measure companies' level of financing constraint. (1) Based on the financing constraint SA index, companies above the industry–year median are classified as the high financing constraint group, and those below the median are classified as the low financing constraint group. (2) Based on dividend payout ratios, companies above the industry–year median are classified as the low financing constraint group, and those below the median are classified as the high financing constraint group.

Columns (1)–(3) in Table 10 indicate that the promotional effect of digitalization on CSR is more significant for companies with low financing constraints; therefore, we can conclude that the promotional effect of digitalization on CSR is also affected by the level of corporate financing constraints.

Table 11
Heterogeneity analysis B.

Variables	*Lncsr*	*Lncsr*	*Lncsr*	*Lncsr*
	Asset cash recovery rate		Size of the enterprise	
	High	Low	Big	Small
	(1)	(2)	(3)	(4)
Digital	0.108**	0.066	0.155***	0.051
	(0.044)	(0.043)	(0.050)	(0.044)
Size	0.110***	0.140***	0.133***	0.143***
	(0.008)	(0.010)	(0.012)	(0.014)
Leverage	−0.652***	−0.676***	−0.665***	−0.767***
	(0.071)	(0.070)	(0.075)	(0.075)
Liquidity	−0.001	0.005	−0.000	0.001
	(0.004)	(0.004)	(0.006)	(0.004)
Roe	3.336***	5.410***	3.962***	4.907***
	(0.156)	(0.179)	(0.161)	(0.166)
Growth	−0.006	−0.004	0.005	−0.017*
	(0.007)	(0.008)	(0.008)	(0.009)
Age	−0.001	0.002	0.002	0.000
	(0.002)	(0.002)	(0.002)	(0.002)
Top1	0.041	0.003	−0.081	0.052
	(0.053)	(0.061)	(0.065)	(0.061)
Board	0.007	0.008	0.001	0.014*
	(0.006)	(0.007)	(0.007)	(0.007)
Indep	0.051	0.226	0.006	0.152
	(0.169)	(0.190)	(0.195)	(0.199)
Dual	0.003	−0.017	0.006	−0.004
	(0.016)	(0.018)	(0.021)	(0.016)
SOE	0.044**	0.090***	0.080***	0.028
	(0.022)	(0.023)	(0.023)	(0.026)
_cons	0.648***	−0.208	0.256	−0.311
	(0.183)	(0.210)	(0.273)	(0.319)
Industry FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Observations	6855	6942	6896	6901
Adjusted R^2	0.379	0.491	0.450	0.473

*, **, and *** denote two-tailed significance at 10%, 5%, and 1%, respectively.

5.3. Heterogeneity analysis: the impact of asset cash recovery rate and firm size

As noted in the theoretical analysis, enterprises' digital transformation will generate resource consumption and there is a certain risk of failure. Companies' digital transformation may result in a shortage in cash flow, causing business distress. From the perspective of risk prevention, enterprises' motivation to fulfill social responsibility will be weakened. In this study, we classify companies based on size and asset cash recovery rate, which equals the net cash flow from operating activities divided by an enterprise's total assets at the end of the period. Companies are classified into large and small groups according to the median industry–year size. Companies are classified into high and low asset cash recovery groups according to the median industry–year asset cash recovery rate. The findings indicate that the smaller an enterprise's size is, the fewer resources it has for collateral warranties and the lower its ability to resist risks will be. The lower the cash recovery rate of assets is, the higher the risk of confronting a cash flow shortage will be when the company undergoes digital transformation or faces a crisis.

The results in Table 11 indicate that the impact of digitalization on CSR is significant only for larger enterprises and those with higher cash recovery rate of assets.

6. Conclusions

This study takes Chinese A-share -listed companies as a research sample, measures the degree of corporate digitalization based on a large sample of text mining, and explores the impact of corporate digitalization on CSR and its underlying mechanism. The relevant results show that, first, corporate digitalization can significantly improve CSR performance and has a significant empowering effect on CSR. Second, regarding the impact path, companies' digitalization can improve the level of R&D innovation, with CSR improvement effects. The heterogeneity analysis results show that corporate digitalization has a more significant CSR improvement effect among companies with lower financing constraints, a higher cash recovery rate of assets, and larger size. The research in this study extends previous literature regarding the drivers of CSR and the non-value effects of corporate digitalization. It also offers an exploratory examination of the digital technology-driven enhancement of corporate willingness and ability to fulfill CSR and provides an empirical basis for further in-depth research on the CSR–digital transformation nexus. In particular, it justifies deepening corporate digital transformation and further investigation of the non-economic consequences of digitalization from a sustainable development

perspective.

The conclusions also have important policy implications. While digital technologies may help companies transform, they may also increase companies' burden, which can reduce the incentive to fulfill CSR. Therefore, governments should develop policies that are more conducive to enterprises' digital transformation by providing subsidies and/or tax reduction. The government should also formulate policies on CSR governance for digital technology engagement to promote corporate digitalization and social sustainability.

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