RESEARCH ARTICLE

Does digital finance promote corporate social responsibility of pollution-intensive industry? Evidence from Chinese listed companies

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Abstract

It is crucial to achieve sustainable development using digital finance to promote the fulfillment of corporate social responsibility. In this paper, we study the impact of digital finance on corporate social responsibility performance of pollution-intensive industry. From the perspective of theoretical mechanism, digital finance could influence corporate social responsibility performance through financing effect. Then, we use the data of Chinese listed companies and the Peking University Digital Financial Inclusion Index of China (PKU_DFIIC) to empirically test the influence of digital finance on corporate social responsibility of pollution-intensive industry. The results show that digital finance is positively related to the fulfillment of corporate social responsibility of pollution-intensive industry. The mechanism test shows that by reducing the information asymmetry in the financial market and making them easier for enterprises to access the financial market, digital finance effectively alleviates the financing constraints of enterprises and then enables enterprises to invest more capital in corporate social responsibility. Furthermore, we find that there are heterogeneous influences of digital finance on the corporate social responsibility performance of different types of enterprises. Specially, enterprises with small scale, located in high informatization and marketization areas and eastern regions of China, and enterprises with high ownership concentration will enjoy more positive impact. By using different indicators to measure digital finance and changing samples for robustness checks, the research conclusions of the paper are still valid. Therefore, government should make more effort to support the development of digital finance, so as to promote corporate social responsibility of pollution-intensive industry and the green and sustainable development of the economy.

Keywords Digital finance · Corporate social responsibility · Financing mechanism · Heterogeneous influence

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Introduction

In recent years, with the rapid development of China's economy, the environmental pollution problem has become more and more serious. China is the second largest economy in the world, and how to implement the concept of green development and promote the sustainable development of the economy has also become an important issue for the government and enterprises. The fulfillment of social responsibilities has gradually attracted the attention of all sectors of society, especially listed companies. Economists have found that the fulfillment of corporate social responsibility plays an important role in promoting the green development of the economy(Nikolaou et al., 2013; Mbanyele et al. 2022). Enterprises in pollution-intensive industry are the main sources of pollution (Lin et al. 2021). And the fulfillment of their social responsibilities is crucial to the sustainable development. According to Ang et al. (2022),

pollution-intensive industries, represented by thermal power, steel, cement, electrolytic aluminum, coal, metallurgy, chemical industry, petrochemical, building materials, paper making, brewing, and pharmaceutical industry, still account for more than half of the total energy consumption, although the energy consumption of these industries has decreased in recent years. These industries have important effect on environmental protection. Therefore, it is important to promote the sustainable development by enhancing the corporate social responsibility of pollution-intensive industry.

At the same time, as a new business form and new model of current financial industry innovation, digital finance formed by the combination of finance and technology is booming. Taking mobile payment as an example, according to the Digital Payments Report 2021 released by Statista in 2021, The Digital Payments segment has a global transaction value of US$5204 billion in 2020 and is the largest segment within FinTech. China is currently the biggest market in the world in Digital Payments, with transaction value reaching US$2496 billion in 2020. Next is the USA, with a digital payment market size of US$1035.4 billion, accounting for 18.915% in the world. In 2020, the size of the European digital payment market is 919.8 billion US dollars, accounting for 16.80% in the world. According to the China Payment Industry Annual Report 2022 released by the China Payment and Clearing Association, the number and amount of mobile payment transactions processed by China domestic banks in 2021 will be 282.67 times and 228.13 times that of 2012, respectively. Mobile payment has become a mainstream retail payment method in China. In 2021, Chinese banking institutions have processed more than 100 billion online payment transactions, with an amount of 2354 trillion yuan, 5.32 times and 2.86 times that of 2012, respectively. The number and amount of online payment transactions processed by Chinese banking institutions increase by 16.32% and 8.25%, respectively, compared with the previous year.

The number and amount of mobile payment transactions processed respectively increase by 22.73% and 21.94%, compared with the previous year.

The overall development of digital finance in China is also very rapid, as shown in Fig. 1. According to The Peking University Digital Financial Inclusion Index of China (PKU_DFIIC), China's digital financial business has achieved leaps and bounds in the past decade. The median value of the digital financial inclusion index in each province in 2011 is 33.6, and in 2020, this index increases to 334.8. The index value grows by an average of 29.1% per year. In 2020, due to the impact of the COVID-19 pandemic, the economic growth rate has dropped significantly, compared with previous years. But the digital financial inclusion index still increases by 5.6%, compared with 2019.

The rise of digital finance has brought huge impact on economic and social development. The Fintech Development Plan (2019–2021) released by People's Bank of China in 2019 clearly points out that digital finance will play an increasingly important role in financing small and micro enterprises, farmers, and innovative entrepreneurs by using multidimensional data. The development of digital finance can alleviate the problems of "financing difficulties" and "financing costs" faced by enterprises. However, few scholars have discussed how digital finance will affect corporate social responsibility.

In view of this, in order to deeply explore the impact of digital finance on corporate social responsibility of pollution-intensive industry and the influence mechanism, this paper will use the data of listed companies of pollution-intensive industry in China's A-share market and construct econometric models to empirically examine the impact of digital finance on corporate social responsibility. We find that digital finance has significantly promoted the fulfillment of corporate social responsibility of pollution-intensive industries. From the perspective of influence channels,

Fig. 1 China's digital finance index (2011–2018) (Index_aggregate means the aggregate digital financial inclusion index. Coverage_breadth means the coverage of breadth index. Usage_depth means the usage depth index. Digitization_level means the digitization level index)
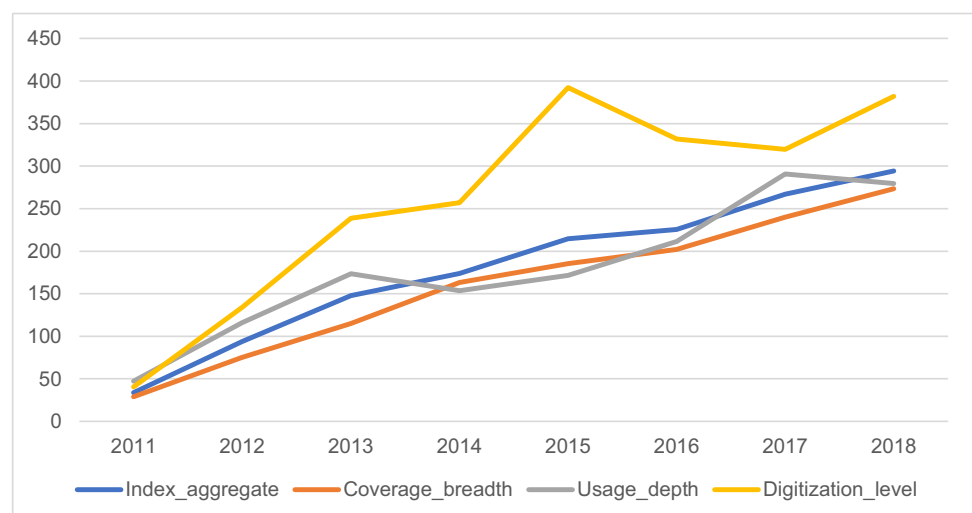
digital finance effectively eases the financing constraints of enterprises by reducing information asymmetry in the financial market and making them easier for enterprises to enter the financial market for financing, thereby allowing enterprises to invest more funds in corporate social responsibility. In addition, we also divide different samples for heterogeneity analysis. Relatively speaking, enterprises with small scale, located in highe informatization and marketization areas and eastern regions of China, and enterprises with highe ownership concentration will enjoy greater positive impact. By using different indicators to measure the development level of digital finance and changing samples for robustness analysis, the research conclusion of the paper still holds. The conclusions of this paper will provide important empirical support for promoting the corporate social responsibility of the pollution-intensive industry through digital finance.

Overall, the marginal contributions of this paper are mainly reflected in the following four aspects. Firstly, economists mainly focus on the effect of digital finance on corporate innovation and economic development (Goldfarb and Tucker 2019; Chen 2020; Yuan et al. 2021; Pan et al. 2022), carbon emissions (Wang and Guo 2022), and green technology innovation (Zhang and Liu 2022; Yu et al. 2020; Rao et al. 2022). However, few scholars discuss how digital finance affects the fulfillment of corporate social responsibility. Therefore, from the perspective of "financing effect," we analyze how digital finance can affect corporate social responsibility by alleviating corporate financing constraints. The paper expands the research field of the micro-enterprise effect of digital finance and profoundly reveals the internal mechanism of digital finance serving the green development of enterprises. Secondly, economists have analyzed the determinants of corporate social responsibility from the perspective of environmental regulation (Zhang and Zhao 2022), tax policy (Lu and Zhu 2021; Bárcena-Ruiz and Sagasta (2022), and corporate governance or management characteristics of enterprises (Jo and Harjoto 2012; Ferrell et al. 2016). Under the background of the rapid development of the global digital economy, this paper discusses the performance of corporate social responsibility from the perspective of digital finance, which enriches the research perspective of the factors affecting corporate social responsibility. Thirdly, by using the corporate social responsibility data of listed companies on Hexun.com and the digital financial inclusion index of the Peking University, we construct many econometric models to empirically examine the actual impact of digital finance on corporate social responsibility of China's pollution-intensive industry and the influence channels. In addition, we divide the sample to test the heterogeneous impact of digital finance on different types of enterprises and get abundant research findings. Fourth,

this research provides empirical evidence to promote the sustainable development through digital finance. Moreover, it should also be noted that digital finance has heterogeneous effect on corporate social responsibility. Therefore, it is necessary to focus on implementing differentiated policies for different regions and different types of enterprises, so as to maximize the role of digital finance in enhancing corporate social responsibility. In conclusion, this paper not only expands the relevant theoretical research on finance and corporate social responsibility, but also provides empirical support for giving play to the role of digital finance in promoting the high-quality development of the real economy.

The remaining structure of this paper is as follows. The second part is the literature review and research hypothesis. The third part introduces the empirical strategy. The fourth part is the analysis of empirical results. The fifth part is the further analysis. The sixth part is the robustness checks. Finally, we give the conclusion and policy implications.

Literature review and research hypothesis

The digital economy has played a significant role in promoting corporate innovation and the development of the real economy by reducing search and entry costs (Goldfarb and Tucker, 2019; Chen 2020; Yuan et al. 2021; Pan et al. 2022). For example, Reza-Gharehbagh et al. (2022) find that the use of digital platforms promotes the development of green technologies. Therefore, as an important part of the digital economy, digital finance also has influenced economic development and corporate financial performance (Deng and Liu 2022). For example, Xia et al. (2022) find that firms in areas with relatively high levels of digital finance development suffer fewer losses from the impact of the COVID-19 pandemic and could recover more quickly. Further, regarding the impact of digital finance on carbon emissions, Wang and Guo (2022) confirm that digital finance is beneficial to reducing CO_2 emissions in Chinese cities. By using spatial econometric models, Zhang and Liu (2022) argue that the synergistic effect of digital finance and green technology innovation has played a significant role in promoting local carbon emission efficiency, but inhibits the carbon emission efficiency of surrounding cities. In addition, digital finance will also promote green technology innovation. Yu et al. (2020) maintain that digital finance significantly promotes the adoption of green control technology of family businesses by improving credit availability and increasing social trust. Feng et al. (2022) find that digital finance significantly promotes the region's green innovation. Rao et al. (2022) also find that digital finance can promote the quantity and quality of corporate green innovation. Finally, some scholars have found that digital finance can significantly reduce the

risk of corporate bankruptcy by improving corporate information disclosure and reducing corporate financial leverage. And this effect is particularly pronounced for small companies and risker firms (Ji et al. 2022). Chen and Zhang (2021) maintain that digital finance has significantly promoted the servitization of Chinese manufacturing enterprises.

There are many factors that affect the performance of corporate social responsibility, and scholars have also analyzed them from different views. From the perspective of external environment, economists have confirmed that market competition (measured by HHI index and the number of players in each industry) is beneficial to corporate social responsibility performance (Leong and Yang 2020). Government policies such as environmental regulation are also important factors affecting corporate social responsibility (See 2009; Vallentin 2015). Zhang and Zhao (2022) test the impact of environmental regulation on corporate social responsibility using China's real-time air quality monitoring policy as a quasi-natural experiment. They find that listed companies in cities that implemented real-time air quality monitoring policies have lower corporate social responsibility. The main reason is that the real-time air quality monitoring policy encourages state-owned enterprises (SOEs) to be environmentally responsible and participates in corporate social responsibility, but it has a negative impact on non-state-owned enterprises (non-SOEs). Non-SOEs have less access to political connections and government subsidies, reducing their motivation to engage in corporate social responsibility. Thus, overall, environmental regulation reduces corporate social responsibility. Tax policy will also affect the corporate social responsibility (Lu and Zhu 2021). Bárcena-Ruiz and Sagasta (2022) point out that when there is no environmental tax, enterprises will not adopt environmental corporate social responsibility. However, if the government implements environmental taxes, then enterprises will adopt environmental corporate social responsibility. Furthermore, energy shock is also an important determinant of corporate social responsibility. A study by Hasan et al. (2022) using US listed company data shows that oil demand shocks have a significant positive impact on corporate social responsibility behavior, while oil supply shocks have a significant negative impact on corporate social responsibility activities. Finally, social media platforms are also conducive to better corporate social responsibility performance (Arrigo et al. 2022). Lu and Zhu (2021) find that tax expenses have both crowding-in and crowding-out effects on corporate social responsibility. However, in general, the crowding-in effect of tax expenses is bigger than the crowding-out effect.

From the perspective of internal factors of enterprises, the characteristics of shareholders will affect corporate social responsibility. The entry of more venture capital will make companies consider to maximize the interests of shareholders, which may have a negative impact on corporate social responsibility. An empirical study by Cheng et al. (2022) using data from China confirms that the corporate social responsibility performance of firms improves significantly after VCs exit the firm. Moreover, corporate governance or management characteristics of enterprises are also important factors affecting corporate social responsibility (Jo and Harjoto 2012; Ferrell et al. 2016). Hegde and Mishra (2019) confirm that married CEO promotes better corporate social responsibility performance. Hartmann and Carmenate (2021) argue that the combination of female and racially diverse members of the board of directors promote corporate social responsibility performance. There is also a significant positive impact on corporate social responsibility when the board consists of women and members of varying levels of education. Lau et al. (2016) maintain that the director's overseas experience, the top management team's overseas work or education experience, and the proportion of the company's state capital have a positive impact on corporate social responsibility, while ownership concentration is not conducive to the improvement of corporate social responsibility. Finally, corporate social responsibility shows a certain peer effect. That is, firm's corporate social responsibility performance comoves with that of other firms headquartered nearby (Li and Wang 2022). Dang et al. (2022) point out that different types of political connections also affect corporate social responsibility, namely symbolic and material connections.

The direct impact of digital finance on corporate is that it can effectively alleviate the financing constraints of enterprises of pollution-intensive industry. The pollution-intensive industry faces greater financial pressure and bears the rising and rigid cost of pollution control (Zhang et al. 2021). Thus, as a new financial business form and model, the inclusive function of digital finance can provide financial services for more market entities, effectively expanding the source of funds and the scope of financial services. Secondly, with the help of emerging information technologies, such as big data, artificial intelligence, blockchain, and 5G, digital finance can effectively alleviate the problem of information asymmetry between borrowers and lenders in the financial market. The existence of information asymmetry makes it difficult for pollution-intensive enterprises to obtain external financing and increases the financing constraints of enterprises (Love 2003). By collecting massive data about individual enterprises and conducting effective analysis, the matching of fund demanders and fund providers can be accurately achieved, and the problem of information asymmetry can be greatly alleviated. Furthermore, digital finance can quickly respond to the financing decisions of enterprises, reduce search costs of transacting parties, achieve economies of

scale in gathering and using large data, achieve cheaper and more secure information transmission, and reduce verification costs. That is, digital finance can reduce the financing cost of enterprises (Thakor 202020202020). In short, the development of digital finance can expand financing sources, improve information asymmetry between borrowers and lenders, reduce corporate financing costs, and improve the corporate financing capabilities of pollution-intensive industries. Therefore, the development of digital finance can alleviate the financing constraints faced by pollution-intensive enterprises.

Moreover, the relaxation of financing constraints of pollution-intensive enterprises can enhance corporate social responsibility (Liu et al. 2021). On the one hand, financing constraints will affect the investment behavior of enterprises (García-Posada Gómez 2019), making enterprises more inclined to invest in low-risk, high-yield projects. Corporate social responsibility involves projects such as environmental protection investment, which increases the operating cost of the enterprise and is not conducive to the profit performance of the enterprise. Therefore, financing constraints hinder corporate social responsibility. Chan et al. (2017) find that when companies face financing constraints (measured by KZ index), companies will not carry out corporate social responsibility activities. Zhang et al. (2019) use China's annual surveys of industrial firms to do the empirical analysis and show that financial constraints significantly hinder firms' environmental investment. An empirical study conducted by Tian and Lin (2019) using World Bank survey data also finds that the increase in the difficulty of enterprises entering the financial market is not conducive to the environmental performance of enterprises. The more serious the financing constraints faced by enterprises, the worse the environmental performance of enterprises. A study by Leong and Yang (2021) using property score matched also argues that financing constraints hinder the overall corporate social responsibility performance of firms. Therefore, an alleviation of corporate financing constraints or an increase in cash flow can significantly contribute to corporate social responsibility (Borghesi et al. 2014). On the other hand, the relaxation of financing constraints can help improve the performance of enterprises (Cao and Leung 2020; Impullitti 2022). And when companies perform better, they will have more funds to invest in socially responsible activities.

Based on the above analysis, we propose the following research hypotheses:

Hypothesis H1: Digital finance promotes the performance of corporate social responsibility of pollution-intensive industry. That is, the higher the level of digital finance, the stronger the performance of corporate social responsibility of pollution-intensive industry.

Hypothesis H2: Digital finance promotes corporate social responsibility of pollution-intensive industry by alleviating financing constraint. And financing constraint is the influence channel. That is, the development of regional digital finance alleviates the financing constraints faced by enterprises, and makes enterprises have more capital to invest in fulfilling their social responsibilities, thereby promoting the corporate social responsibility performance of pollution-intensive industry.

Empirical strategy

Econometric model

In order to empirically test the impact of digital finance on corporate social responsibility of pollution-intensive industry, according to Wang et al. (2021), we set the empirical model as follows:

$$CSR_{ict} = \beta_0 + \beta_1 DigitalFinance_{ct} + \eta' X_{ict} + \phi_i + \omega_t + \xi_{ict}$$

CSR is the corporate social responsibility performance variable, $DigitalFinance$ is the digital finance variable, and X includes a series of firm-level control variables. ϕ_i is the firm fixed effect. ω_t is the time fixed effect. ξ_{ict} is the random error term.

Variables

For corporate social responsibility (CSR) variable, according to Ang et al.(2022) and based on China's hexun.com's CSR evaluation scores, we measure the degree of corporate social responsibility of listed companies. Hexun.com gives corporate social responsibility scores in five aspects, including shareholder responsibility; employee responsibility; supplier, customer, and consumer rights and interests responsibility; environmental responsibility; and social responsibility. The larger the value of the index, the higher the degree of corporate social responsibility performance. In addition, the original value of this indicator may not be a good measure of the change of corporate social responsibility performance. Therefore, we use the growth rate of this score to construct CSR indicators to reflect the performance of corporate social responsibility. Specifically, CSR index = (current year's CSR score-last year's CSR score)/ last year's CSR score.

The digital finance (*DigitalFinance*) index is measured by the Digital Financial Inclusion Index of the Peking University, which is constructed by Guo et al. (2020). Many scholars have used this index when studying the influence of digital finance on enterprise innovation, bank competition, enterprise financing, and economic

development (Rao et al. 2022; Ji et al. 2022). Guo et al. (2020) construct China's digital financial inclusion index system at three levels, provinces, cities, and counties, respectively. And the index includes three dimensions, coverage breadth, usage depth, and digitization, as shown in Table 1.

Guo et al. (2020) firstly adopt the logarithmic efficiency function method to conduct dimensionless processing of each index. The logarithmic efficiency function is as follows:

$$d = \frac{\log x - \log x^l}{\log x^h - \log x^l} * 100$$

After that, the weight of each index is determined. And then the total index is gradually synthesized from the bottom up.

Furthermore, in order to obtain robust estimation results, we also control a series of firm-level variables, as shown below:

The company's age (lnAge) is expressed as the logarithmic form of the statistical time of the sample minus the time of the company going public plus 1. Enterprises with older age have more management experience and stronger sense of social responsibility. Therefore, age may have a positive impact on the performance of corporate social responsibility.
The enterprise size (lnSize), the total assets at the end of the year. And its logarithmic form is taken in the paper.
The Cashratio, (cash and cash equivalents)/total assets.
PEratio, the current closing price/(net profit in the last year's annual report value/paid-out capital at the end of the current period).
Capital turnover (Capturn), the operating income divided by total assets.
Leverage (Lev) is expressed by the ratio of total liabilities to total assets.

Table 2 Summary statistics

Variable	Obs	Mean	Std.Dev	Min	Max
CSR	2650	0.1997	12.4808	−273.8889	340.0000
DigitalFinance	2617	214.7593	39.7400	108.9200	302.9827
lnAge	2650	2.3726	0.6641	0.0000	3.2958
lnSize	2650	22.5416	1.3407	18.8845	28.5200
Cashratio	2650	0.1275	0.1063	0.0003	0.6982
Capturn	2650	0.6207	0.3972	0.0269	3.8983
PEratio	2329	106.6093	395.7055	1.6427	11,413.3900
Lev	2650	0.4319	0.2070	0.0167	1.8463
Duality	2650	0.2279	0.4196	0.0000	1.0000
Mhldn	2650	0.0689	0.1360	0.0000	0.7907

For the Duality variable, if the CEO is the chairman of the enterprise, then the value of Duality variable is equal to 1. Otherwise, the value of Duality variable is equal to 0.
Management shareholding (Mhldn), management shares/total shares.

Table 1 Digital finance indicators

	Level 1 dimension	Level 2 dimension
Digital finance	Coverage breadth	Account coverage
		Payment business
		Money fund business
	Usage depth	Credit business
		Insurance business
		Investment business
		Fiduciary business
	Digitization level	Mobile
		Affordable
		Fiduciary
		Convenient

Table 3 Basic results

	(1)	(2)	(3)	(4)
DigitalFinance	0.1296**	0.1290**	0.1604***	0.1575***
	(0.0599)	(0.0601)	(0.0585)	(0.0584)
lnAge		−0.0613	−0.1772	−0.3398
		(2.3453)	(2.2898)	(2.4349)
lnSize		0.1915	0.9715	0.9224
		(1.1505)	(1.2561)	(1.2554)
Cashratio			−7.5709*	−7.4040*
			(4.4938)	(4.4907)
Capturn			2.8912	3.0941*
			(1.8208)	(1.8215)
PEratio			0.0048***	0.0048***
			(0.0008)	(0.0008)
Lev			−6.2302	−6.0237
			(3.9521)	(3.9502)
Duality				−2.3497**
				(1.0639)
Mhldn				−1.5735
				(5.8876)
Constant	−21.2604**	−25.2989	−46.0065	−43.6409
	(9.8019)	(26.2432)	(28.7065)	(28.8606)
Year fixed effect	Yes	Yes	Yes	Yes
Firm fixed effect	Yes	Yes	Yes	Yes
Observations	2617	2617	2298	2298
R^2	0.2069	0.2069	0.3085	0.3105

Parentheses are robust standard errors. ***, **, and * indicate significance levels of 1%, 5%, and 10%, respectively

Data source

The enterprise data used in this paper is mainly from CSMAR database, and the time span is 2014–2018. The variables of lnAge, lnSize, Cashratio, PEratio, Capturn, Lev, Duality, and Mhldn are all collected from this database. In addition, we focus on the corporate social responsibility performance of pollution-intensive industry. So we define and classify pollution-intensive industry based on the Guidelines on Environmental Information Disclosure of Listed Companies issued by the Ministry of Ecology and Environment of China. Specifically, in the Guidelines on Environmental Information Disclosure of Listed Companies published by the Ministry of Ecology and Environment, the pollution-intensive industries include thermal power, steel, cement, electrolytic aluminum, coal, metallurgy, chemical industry, petrochemical, building materials, paper making, brewing, pharmaceutical, fermentation, textile, leather, and mining industries. According to Wang et al. (2021), CSR score data come from Hexun.com (http://www.hexun.com/). DigitalFinance indicators are from the digital financial inclusion index constructed by the Digital Finance Center of Peking University (Guo et al., 2020). We use the data at the prefecture level and city level. Further, the enterprises of ST, *ST, and SST are deleted from the sample. We also delete the enterprises which the main variable information is missing.

Summary statistics

Table 2 shows the descriptive statistics of the variables. According to Table 2, the development level of digital finance in different cities varies greatly. For example, the maximum value is 302.9827, and the minimum value is 108.9200. The maximum value of CSR is 340.0000, and the minimum value is -273.8889. Next, we will do the empirical analysis to test the effect of digital finance on corporate social responsibility of pollution-intensive industry.

Table 4 Influence mechanism (1)

	Model 1	Model 2	Model 3	Model 4
	State-owned enterprise	State-owned enterprise	Non-state-owned enterprise	Non-state-owned enterprise
DigitalFinance	0.0156	0.0188	0.2071***	0.2194***
	(0.1224)	(0.1133)	(0.0603)	(0.0660)
lnAge		-0.8762		2.0087
		(6.0365)		(2.6755)
lnSize		0.0561		1.0653
		(2.5759)		(1.4257)
Cashratio		-16.8440^*		-2.0775
		(9.2300)		(4.9471)
Capturn		3.0103		2.7649
		(3.3504)		(2.1381)
PEratio		0.0080***		0.0001
		(0.0011)		(0.0012)
Lev		-7.9647		-3.4196
		(7.4530)		(4.5627)
Duality		-0.3747		-3.3916^{***}
		(1.8013)		(1.3020)
Mhldn		-18.0664		-2.0071
		(75.0324)		(5.5604)
Constant	-2.7929	0.9717	-34.1754^{***}	-61.6091^*
	(19.6720)	(62.0584)	(9.9927)	(32.5176)
Year fixed effect	Yes	Yes	Yes	Yes
Firm fixed effect	Yes	Yes	Yes	Yes
Observations	1132	961	1,485	1,337
R^2	0.2043	0.3918	0.2161	0.2413

Parentheses are robust standard errors. ***, **, and * indicate significance levels of 1%, 5%, and 10%, respectively

Results

Basic results

The basic regression results are shown in Table 3. In model 1, we only control year fixed effect and firm fixed effect, and no other control variables are added. According to the results of model 1, the coefficient of DigitalFinance is positive and significant at the level of 5%. This shows that the development of regional digital finance has significantly promoted pollution-intensive enterprises to fulfill more corporate social responsibilities. After adding the variables lnAge and lnSize, model 2 shows that the coefficient of DigitalFinance is still significantly positive. Model 3 adds control variables of corporate financial information, including Cashratio, Capturn, PEratio, and Lev. Model 4 adds more control variables, including Duality and Mhldn. Obviously, in model 3 and model 4, the coefficients of DigitalFinance are all significantly positive. It means that digital finance can significantly promote corporate social responsibility

performance. Generally speaking, the development of digital finance can make them more easier for enterprises to finance in the financial market and make them have enough capital to fulfill their social responsibilities. Therefore, the development of regional digital finance promotes the fulfillment of corporate social responsibility. This also verifies the research hypothesis H1.

Channel tests

According to Table 3, digital finance can promote the fulfillment of corporate social responsibility of pollution-intensive enterprises. According to the theoretical analysis, digital finance influences corporate social responsibility mainly through financing channels. Therefore, we test the influence mechanism of digital finance on corporate social responsibility.

On the one hand, we classify the firms according to their ownership. According to the nature of the final controller of the enterprise, we divide the sample into state-owned

Table 5 Influence mechanism (2)

	Model 1	Model 2	Model 3	Model 4
	Low leverage enterprises	Low leverage enterprises	High leverage enterprises	High leverage enterprises
DigitalFinance	0.1857***	0.2012***	0.0884	0.1286
	(0.0285)	(0.0285)	(0.1120)	(0.1155)
lnAge		0.1975		−1.5056
		(1.0444)		(5.6496)
lnSize		1.0603*		0.5115
		(0.5921)		(2.5776)
Cashratio		−2.0743		−16.2124
		(1.8026)		(12.1511)
Capturn		1.3588		3.9043
		(0.9784)		(3.3526)
PEratio		0.0003		0.0062***
		(0.0005)		(0.0013)
Lev		−0.1584		−10.3519
		(1.9052)		(7.8826)
Duality		−1.1341**		−3.5139*
		(0.5329)		(2.0395)
Mhldn		−0.3315		−5.8955
		(2.4395)		(14.5736)
Constant	−30.3484***	−56.6429***	−14.5576	−24.3571
	(4.6566)	(13.9998)	(18.3480)	(57.2675)
Year fixed effect	Yes	Yes	Yes	Yes
Firm fixed effect	Yes	Yes	Yes	Yes
Observations	1305	1195	1312	1103
R^2	0.2493	0.3503	0.2066	0.3161

Parentheses are robust standard errors. ***, **, and * indicate significance levels of 1%, 5%, and 10%, respectively

Table 6 Different size

	Model 1	Model 2	Model 3	Model 4
	Small-scale enterprise	Small-scale enterprise	Large-scale enterprise	Large-scale enterprise
DigitalFinance	0.1996**	0.2174***	0.0460	0.0985
	(0.0907)	(0.0767)	(0.0772)	(0.0911)
lnAge		0.0104		−1.9822
		(3.0650)		(4.7080)
lnSize		1.7558		0.5113
		(1.9609)		(1.6721)
Cashratio		−9.3344*		−0.8997
		(5.4064)		(8.1385)
Capturn		4.8805*		1.1851
		(2.7907)		(2.4416)
PEratio		0.0063***		−0.0009
		(0.0009)		(0.0017)
Lev		−6.0666		−6.1088
		(5.4258)		(5.8595)
Duality		−2.2921		−2.4390
		(1.5229)		(1.4903)
Mhldn		−1.4199		−0.8186
		(6.5462)		(13.7912)
Constant	−32.4538**	−71.8219*	−7.6975	−20.3919
	(14.7905)	(43.1913)	(12.6837)	(40.6160)
Year fixed effect	Yes	Yes	Yes	Yes
Firm fixed effect	Yes	Yes	Yes	Yes
Observations	1315	1149	1302	1149
R^2	0.2059	0.3849	0.2108	0.2373

Parentheses are robust standard errors. ***, **, and * indicate significance levels of 1%, 5%, and 10%, respectively

enterprises and non-state-owned enterprises. The results are shown in Table 4. According to the regression results, in the sample of state-owned enterprises, as shown in model 1 and model 2, the coefficients of DigitalFinance are not significant, which indicates that the influence of DigitalFinance on the performance of corporate social responsibility of state-owned enterprises is not obvious. In the sample of non-state-owned enterprises, according to the results of model 3 and model 4, the coefficients of DigitalFinance are positive, both at the significance level of 1%. This means that digital finance can effectively promote the performance of non-state-owned corporate social responsibility. Generally speaking, due to their special status, state-owned enterprises have great advantages in terms of credit and are relatively easy to obtain credit resources (Li et al. 2021). Non-state-owned enterprises generally face credit constraints. By comparing the regression results of the two samples, it can be concluded that the development of digital finance plays a more obvious role in promoting the performance of corporate social responsibility of non-state-owned enterprises. This means that digital finance can promote the performance

of corporate social responsibility by alleviating financing constraints, verifying the research hypothesis H2.

In addition, in order to further illustrate that digital finance can promote the improvement of corporate social responsibility through the mechanism of easing financing constraints, enterprises are divided into high leverage enterprises and low leverage enterprises. The results are shown in Table 5. The ratio is measured according to the proportion of the short-term borrowing to the total assets of the enterprise. If this ratio is higher than the median of the sample, it is classified as a high leverage enterprise. Otherwise, it is a low leverage enterprise. Enterprises with high leverage ratio can obtain a higher proportion of short-term borrowing in the total assets, indicating that such enterprises face less financing constraints, while enterprises with low leverage ratio face greater financing constraints. From the regression results, model 1 shows that the coefficient of DigitalFinance is positive. After adding more control variables, model 2 shows that the coefficient of DigitalFinance is still positive and significant at the level of 1%. This means that digital finance significantly promotes the performance of corporate social responsibility

Table 7 Different informatization level

	Model 1	Model 2	Mode 3	Mode 4
	High informatization level	High informatization level	Low informatization level	Low informatization level
DigitalFinance	0.1653***	0.2255***	0.0847	0.0752
	(0.0623)	(0.0630)	(0.1081)	(0.1030)
lnAge		−2.7438		2.7955
		(2.6664)		(4.1894)
lnSize		0.8374		1.6121
		(1.3572)		(2.2110)
Cashratio		−5.9303		−4.9470
		(4.7865)		(8.0286)
Capturn		4.3728**		2.2882
		(2.1053)		(2.9855)
PEratio		0.0080***		−0.0001
		(0.0008)		(0.0014)
Lev		−7.2862		−3.0949
		(4.4555)		(6.6014)
Duality		−3.2847***		−1.8306
		(1.1748)		(1.8107)
Mhldn		−1.3627		−0.7565
		(6.7698)		(9.7217)
Constant	−27.2366***	−48.5414	−13.8829	−52.7163
	(10.2839)	(31.7553)	(17.5421)	(49.9480)
Year fixed effect	Yes	Yes	Yes	Yes
Firm fixed effect	Yes	Yes	Yes	Yes
Observations	1334	1162	1283	1136
R^2	0.2222	0.4199	0.2007	0.2619

Parentheses are robust standard errors. ***, **, and * indicate significance levels of 1%, 5%, and 10%, respectively

of low leverage enterprises. However, in model 3 and model 4, the coefficients of DigitalFinance are not significant. This shows that digital finance has no significant impact on the performance of corporate social responsibility of high leverage enterprises. This also confirms that digital finance can improve the performance of corporate social responsibility by reducing the corporate financing constraints, which again verifies the research hypothesis H2.

Further analysis

Firm's size

The total assets of enterprises at the end of the year are used to measure the size of enterprises. If enterprise's size is bigger than the median, then it is a large-scale enterprise. Otherwise, it is a small-scale enterprise. The empirical results are shown in Table 6. According to the regression results, the coefficients of digital finance in model 1 and model 2 are significantly positive, while the coefficients of digital finance

in model 3 and Model 4 are not significant. This means that digital finance has a significant positive effect on the performance of small-scale corporate social responsibility, but has no obvious influence on the performance of large-scale corporate social responsibility. The financing constraints faced by small-scale enterprises are generally larger than those faced by large-scale enterprises. Therefore, the development of digital finance can alleviate the "financing difficulties" and "financing costs" of small-scale enterprises, thus enabling small enterprises to have enough funds to fulfill their corporate social responsibility. Therefore, compared with large-scale enterprises, small-scale enterprises are more obviously affected by digital finance, which can better encourage enterprises to fulfill their corporate social responsibility.

Different informatization level

Information infrastructure plays an important role for the using of digital finance, such as mobile networks. Therefore, different levels of informatization in different regions may lead to heterogeneous impacts of digital finance on corporate social

Table 8 Different marketization level

		Model 1	Model 2	Model 3	Model 4
		High marketization level	High marketization level	Low marketization level	Low marketization level
DigitalFinance		0.2301	0.2691*	0.1061***	0.1568***
		(0.1472)	(0.1417)	(0.0399)	(0.0364)
lnAge			0.5579		−0.9588
			(3.9062)		(2.0049)
lnSize			1.4162		0.3893
			(2.1888)		(0.8992)
Cashratio			−11.5805		−1.1996
			(7.6959)		(3.2883)
Capturn			3.1640		1.6851
			(2.9769)		(1.4343)
PEratio			0.0061***		0.0000
			(0.0011)		(0.0009)
Lev			−9.8729		−1.1938
			(6.8456)		(2.8373)
Duality			−1.7048		−2.5424***
			(1.6772)		(0.8741)
Mhldn			−1.7362		−2.7894
			(8.8163)		(5.3214)
Constant		−40.1728	−75.8690	−15.9810***	−29.2287
		(25.5952)	(52.2068)	(6.0427)	(21.0703)
Year fixed effect		Yes	Yes	Yes	Yes
Firm fixed effect		Yes	Yes	Yes	Yes
Observations		1422	1295	1195	1003
R^2		0.2049	0.3068	0.2340	0.3968

Parentheses are robust standard errors. ***, **, and * indicate significance levels of 1%, 5%, and 10%, respectively

responsibility performance. According to the information levels of the regions in which the enterprises are located, enterprises are divided into high informatization level region sample and low informatization level region sample.[1] It can be seen from model 1 and model 2 in Table 7 that the coefficients of DigitFinance are positive, both significant at the 1% level. However, in model 3 and model 4, the coefficients of DigitFinance are not significant. Therefore, it can be seen from the regression results that digital finance plays a more obvious role in areas with high informatization level. Regions with high

levels of informatization provide a sound information infrastructure for digital finance to work. And the higher the level of informatization can also promote the development of digital finance, which can also enhance the positive impact of digital finance on the performance of corporate social responsibility.

Different marketization level

Since the reform and opening up, China's economic development has made remarkable achievements. And that cannot happen without China's market reforms. Therefore, the level of marketization will also affect the role of digital finance in promoting the fulfillment of corporate social responsibility.[2]

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[1] We use the "number of computers used per 100 people" in each province in the China Statistical Yearbook to measure the level of regional informatization development. We firstly collect the number of computers used per 100 people in each province from 2014 to 2018 from China Statistical Yearbook. Then, the average value of the informatization level of each province from 2014 to 2018 is calculated. If the average informatization level of the province is higher than the median of the average informatization level of all provinces, it is defined as a high informatization level area. Otherwise, it is defined as a low informatization level area.

[2] We use the Marketization index of China's provinces constructed by Wang Xiaolu et al. (2021) to measure the marketization development level of the region. We calculate the average value of the marketization level of each province from 2014 to 2018. If the average marketization level of the province is higher than the median of the average marketization level of all provinces, it is defined as a high marketization area. Otherwise, it is defined as a low marketization area.

According to Table 8, it can be seen that digital finance has significantly promoted the performance of corporate social responsibility in pollution-intensive industries for enterprises in both high and low marketization regions. However, the coefficient of DigitalFinance in model 2 is larger than that in model 4. This means that the improvement of the marketization level is conducive to the better function of digital finance. The higher the marketization level is, the better the development environment or business environment of enterprises will face. Therefore, it is more conducive to promote the performance of corporate social responsibility in high marketization areas.

Eastern and western regions

We divide the sample into enterprises in eastern China and enterprises in western China. According to Table 9, in the regression results of the eastern region and western regions, the coefficients of digital finance are all significantly positive. But compared with the enterprises in the western regions, the influences of digital finance on the performance of corporate social responsibility in the eastern region are

more obvious. The eastern region has a higher level of economic development and better infrastructure, which are more conducive for digital finance to promote the performance of corporate social responsibility.

Ownership concentration

Finally, ownership concentration may also influence the effect of digital finance on corporate social responsibility. Thus, if the ownership concentration of an enterprise is greater than the median of the sample, it belongs to a high ownership concentration enterprise. Otherwise, it belongs to a low ownership concentration enterprise. According to Table 10, it can be seen that in the sample of enterprises with low ownership concentration, the coefficients of digital finance are not significant. While in the sample of enterprises with high ownership concentration, the coefficients of digital finance are significantly positive at the 1% level. Compared with enterprises with low ownership concentration, enterprises with high ownership concentration have higher decision-making efficiency. Moreover, the largest shareholder has a high shareholding ratio, so the business performance

Table 9 Different regions

	Model 1	Model 2	Model 3	Model 4
	Eastern region	Eastern region	Western region	Western region
DigitalFinance	0.2178*	0.2764**	0.1128***	0.1593***
	(0.1319)	(0.1289)	(0.0425)	(0.0388)
lnAge		− 0.4654		0.2408
		(3.9011)		(1.9626)
lnSize		1.1901		0.4952
		(2.0806)		(0.9548)
Cashratio		− 11.0209		− 0.5215
		(7.2583)		(3.6051)
Capturn		3.3199		1.2065
		(2.8701)		(1.5119)
PEratio		0.0063***		− 0.0008
		(0.0011)		(0.0009)
Lev		− 8.8355		− 2.3989
		(6.4906)		(3.0163)
Duality		− 1.5987		− 2.7702***
		(1.5608)		(0.9865)
Mhldn		− 1.6508		− 2.8670
		(8.8518)		(5.1842)
Constant	− 37.6647*	− 70.3357	− 17.0380***	− 33.7145
	(22.7411)	(49.0285)	(6.4406)	(22.1129)
Year fixed effect	Yes	Yes	Yes	Yes
Firm fixed effect	Yes	Yes	Yes	Yes
Observations	1514	1371	1103	927
R^2	0.2052	0.3106	0.2272	0.3795

Parentheses are robust standard errors. ***, **, and * indicate significance levels of 1%, 5%, and 10%, respectively

of the enterprise is closely related to its income. Therefore, the largest shareholder will pay more attention to the operation of the enterprise, which is conducive to the development of the enterprise. After enterprises get better development, digital finance will play a more obvious role in promoting the performance of corporate social responsibility.

Robustness checks

Replace the explanatory variables

Firstly, we use the coverage width to measure the development of digital finance, and the results are shown in Table 11. In model 3 and model 4, the coefficients of width are significantly positive, which indicates that the development of digital finance promotes the performance of corporate social responsibility.

Secondly, we use the usage depth to measurement of digital finance, and the results are shown in Table 12. According to the regression results, the coefficients of depth in model 1,

model 2, and model 3 are all significantly positive. In model 4, its coefficient is 0.1052, which is significant at the 1% level. This also shows that the development of digital finance can promote the performance of corporate social responsibility.

Replace the samples

Finally, in order to further test the robustness of the conclusions, we remove the data with incomplete years from the samples and do the robustness test of the replacement samples. According to the regression results in Table 13, the coefficients of Digital-Finance are all significantly positive. This proves that digital finance can significantly enhance the performance of corporate social responsibility again. Thus, our results are robust.

Conclusion and policy implications

Digital finance could influence corporate social responsibility performance through financing effect. In this paper, we use the data of Chinese listed companies and the Peking

Table 10 Different ownership concentration

	Model 1	Model 2	Model 3	Model 4
	Low ownership concentration	Low ownership concentration	High ownership concentration	High ownership concentration
DigitalFinance	0.1560	0.1936	0.1095***	0.1498***
	(0.1219)	(0.1231)	(0.0424)	(0.0382)
lnAge		−0.2929		0.0915
		(5.4109)		(1.5363)
lnSize		1.3587		1.0597
		(2.3108)		(0.9290)
Cashratio		−14.2923*		−0.7857
		(8.4105)		(3.2163)
Capturn		4.2108		1.9179
		(3.6363)		(1.2400)
PEratio		0.0062***		−0.0010
		(0.0012)		(0.0009)
Lev		−9.3492		−3.8523
		(7.6513)		(2.7663)
Duality		−3.2854*		−1.5919**
		(1.9155)		(0.7941)
Mhldn		−2.6192		−1.0067
		(10.4331)		(4.6351)
Constant	−25.4682	−56.9413	−18.0750***	−47.6736**
	(19.9267)	(55.1194)	(6.9420)	(20.9692)
Year fixed effect	Yes	Yes	Yes	Yes
Firm fixed effect	Yes	Yes	Yes	Yes
Observations	1312	1142	1305	1156
R^2	0.2042	0.3104	0.2300	0.3637

Parentheses are robust standard errors. ***, **, and * indicate significance levels of 1%, 5%, and 10%, respectively

University Digital Financial Inclusion Index of China (PKU_DFIIC) to empirically test the influence of digital finance on corporate social responsibility of the pollution-intensive industry. The results show that digital finance is positively related to the fulfillment of corporate social responsibility of pollution-intensive industry. The mechanism test shows that by reducing the information asymmetry in the financial market and making them easier for enterprises to access the financial market, digital finance effectively alleviates the financing constraints of enterprises and then enables enterprises to invest more capital in corporate social responsibility. Furthermore, we find that there are heterogeneous influences of digital finance on the corporate social responsibility performance of different types of enterprises. Specially, enterprises with small scale, located in high informatization and marketization areas and eastern regions of China, and enterprises with high ownership concentration will enjoy greater positive impact. By using different indicators to measure digital finance and changing samples for robustness analysis, the research conclusions of the paper are still valid.

This study provides important policy implications for promoting the development of digital finance to enhance the fulfillment of corporate social responsibility. Firstly, the results in this paper show that digital finance has significantly promoted the corporate social responsibility performance of the pollution-intensive industry. Therefore in order to promote the high-quality development of digital finance, government should make more support to the applications of digital inclusive finance and, in terms of hardware, actively promote digital finance-related infrastructure investment, including information technology facilities and digital platforms. And these measures can increase the application and promotion of digital technology, so that more enterprises can enjoy the financing convenience brought by the development of digital finance. In terms of software, attention should be paid to the cultivation of talents in digital finance-related fields, especially the cultivation of high-end technical talents responsible for the development of digital finance, so as to provide talent support for the development of digital finance. At the same time, government should actively promote the application of information technologies such as big data,

Table 11 Regression results using coverage width as the explanatory variable

	Model 1	Model 2	Model 3	Model 4
Width	0.0639	0.0638	0.1139*	0.1095*
	(0.0627)	(0.0627)	(0.0619)	(0.0619)
lnAge		−0.0230	−0.1536	−0.3802
		(2.3476)	(2.2926)	(2.4381)
lnSize		0.3377	1.0873	1.0338
		(1.1494)	(1.2570)	(1.2564)
Cashratio			−7.3692	−7.2139
			(4.5015)	(4.4984)
Capturn			2.9032	3.1036*
			(1.8238)	(1.8245)
PEratio			0.0049***	0.0049***
			(0.0008)	(0.0008)
Lev			−5.5698	−5.3754
			(3.9553)	(3.9532)
Duality				−2.3418**
				(1.0656)
Mhldn				−2.0319
				(5.8923)
Constant	−11.2082	−18.6746	−42.5389	−39.5997
	(10.9160)	(27.1816)	(29.5184)	(29.6463)
Year fixed effect	Yes	Yes	Yes	Yes
Firm fixed effect	Yes	Yes	Yes	Yes
Observations	2617	2617	2298	2298
R^2	0.2055	0.2056	0.3068	0.3088

Parentheses are robust standard errors. ***, **, and * indicate significance levels of 1%, 5%, and 10%, respectively

Table 12 Regression results using usage depth as the explanatory variable

	Model 1	Model 2	Model 3	Model 4
Depth	0.0785*	0.0781*	0.1069***	0.1052***
	(0.0417)	(0.0419)	(0.0407)	(0.0407)
lnAge		0.2008	0.1061	−0.0495
		(2.3473)	(2.2909)	(2.4372)
lnSize		0.1395	0.8434	0.7961
		(1.1537)	(1.2589)	(1.2582)
Cashratio			−7.5952*	−7.4264*
			(4.4946)	(4.4914)
Capturn			3.0766*	3.2780*
			(1.8243)	(1.8249)
PEratio			0.0048***	0.0049***
			(0.0008)	(0.0008)
Lev			−6.1422	−5.9379
			(3.9518)	(3.9498)
Duality				−2.3648**
				(1.0640)
Mhldn				−1.4940
				(5.8897)
Constant	−11.3805*	−14.8712	−33.1105	−31.0385
	(6.0288)	(25.2331)	(27.6970)	(27.8446)
Year fixed effect	Yes	Yes	Yes	Yes
Firm fixed effect	Yes	Yes	Yes	Yes
Observations	2617	2617	2298	2298
R^2	0.2065	0.2065	0.3082	0.3102

Parentheses are robust standard errors. ***, **, and * indicate significance levels of 1%, 5%, and 10%, respectively

artificial intelligence, blockchain, and cloud computing, and develop more service scenarios for digital finance. Increasing the publicity of digital finance in places where the development of digital finance is relatively weak is also important. This will make enterprises understand digital finance as soon as possible and then enjoy the bonus brought by the development of digital finance.

Secondly, to play the role of digital finance in enhancing the fulfillment of corporate social responsibility, it is inseparable from the support of regional informatization and marketization development. Informatization can provide hardware support for the development of digital finance. The development of marketization provides a good business environment for the development of digital finance. The empirical results of this paper also show that digital finance has a greater positive impact on the corporate social responsibility performance of companies in high informatization and high marketization regions. Therefore, the investment in regional basic information facilities should be further increased. Government should build a unified large market to improve the level of market-oriented development in the region, thereby providing a good external environment for

the popularization of digital finance, and better promoting enterprises in heavily polluting industries to fulfill their social responsibilities.

Furthermore, the role of digital finance in promoting the fulfillment of corporate social responsibility in different regions shows a certain degree of heterogeneity. Overall, the economic level of the eastern region is relatively developed, which can better promote the development of digital finance. Moreover, the better financial environment in the eastern region also provides more financing opportunities for enterprises, which is more conducive to promote the fulfillment of corporate social responsibility. On the contrary, the low level of economic development in the central and western regions is not conducive to give full play to the role of digital finance in promoting corporate social responsibility. Therefore, while vigorously promoting the development of digital finance, the government should also pay attention to implementing differentiated policies for different regions. Certain policy preferences and inclinations should be given to the central and western regions to accelerate the coverage of digital financial services in the central and western regions, so as to more effectively alleviate the problems of "financing difficulties" and "expensive financing" for enterprises in the central and western regions.

Finally, digital finance brings new opportunities for corporate social responsibility performance of the pollution-intensive industry, thus promoting sustainable development. However, we must also pay attention to potential financial risks that may arise in the process of digital finance development, such as big data processing, platform selection, financial information security, and other issues. Therefore, in the process of promoting the development of digital finance, we must pay attention to the prevention of financial risks. It is necessary to increase the supervision of digital financial platforms, continuously improve the supervision system, and prevent the occurrence of financial risks. Only by strictly adhering to the bottom line of financial risks can the positive role of digital finance be better played.

Table 13 Regression results of replacement samples

	Model 1	Model 2	Model 3	Model 4
DigitalFinance	0.1428**	0.1428**	0.1814***	0.1788***
	(0.0654)	(0.0656)	(0.0645)	(0.0644)
lnAge		−1.1555	−1.5917	−1.8269
		(3.2006)	(3.1158)	(3.2563)
lnSize		0.2335	1.0283	0.9658
		(1.2554)	(1.3720)	(1.3712)
Cashratio			−9.0919*	−8.7703*
			(5.0685)	(5.0664)
Capturn			2.9388	3.1554
			(1.9208)	(1.9222)
PEratio			0.0048***	0.0048***
			(0.0008)	(0.0008)
Lev			−7.0288*	−6.7010
			(4.2399)	(4.2404)
Duality				−2.4302**
				(1.1316)
Mhldn				−2.9812
				(7.7851)
Constant	−23.3887**	−25.9882	−47.0786	−44.2889
	(10.6916)	(29.1213)	(31.8916)	(31.9714)
Year fixed effect	Yes	Yes	Yes	Yes
Firm fixed effect	Yes	Yes	Yes	Yes
Observations	2404	2404	2098	2098
R^2	0.2072	0.2073	0.3093	0.3113

Parentheses are robust standard errors. ***, **, and * indicate significance levels of 1%, 5%, and 10%, respectively

Declarations

Ethics approval Not applicable.

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