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Digital Technology Innovation and Corporate Environmental Responsibility: A Resource Acquisition Perspective

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Abstract: Using annual panel data of A-share listed companies in Shanghai and Shenzhen from 2011 to 2024, this paper examines the impact of digital technology innovation on corporate environmental responsibility. The results show that, first, corporate digital technology innovation significantly improves firms' actual performance in environmental responsibility. Specifically, it both reduces symbolic environmental disclosure and promotes substantive environmental responsibility performance. Second, the mediation analysis indicates that digital technology innovation has a significant resource effect: firms can improve their environmental responsibility performance by acquiring more digital resources, knowledge resources, and credit resources. Third, the positive effect of corporate digital technology innovation on environmental responsibility is more pronounced among firms with higher levels of slack resources and firms subject to stronger environmental regulation. Fourth, further analysis shows that digital technology innovation can guide firms to undertake environmental responsibility from both the breadth and depth of application, exerting a positive influence in the process.

Keywords: Digital technology; environmental responsibility; resources; green development.

1. Introduction

As digital transformation is defined as an important direction of national strategy, firms have responded to the call and actively engaged in the exploration and practice of digital technologies. Digital technology innovation has become an important means for firms to maintain competitiveness in the market (Berawi et al., 2020)[1]. However, excessive pursuit of the high speed of digital economy development may increase environmental risks. The construction of digital equipment and infrastructure needs to rely on a large amount of energy and raw materials, and this process will produce a large amount of carbon emissions (Du et al., 2023)[2]. The 2024 Digital Economy Report released by the United Nations points out the environmental costs caused by the development of the digital industry. The world is facing the problems of resource depletion, rising energy consumption and digital waste pollution. Therefore, the corporate digitalization should not only focus on economic benefits, but also conform to the overall social and public interests and become responsible digitalization (De Giovanni, 2021)[3]. Cardinali and De Giovanni (2022)[4] pointed out that firms can achieve responsible digitalization when building digital technology portfolios, while meeting the dual goals of digital transformation and green development. On the one hand, in the process of technological innovation, Firms should not pursue technological actions at the expense of the environment; rather, they must take into account the long-term ecological and social impacts as part of their efforts to advance sustainable development ; on the other hand, firms can use digital technology to obtain more resources and improve resource utilization efficiency, and promote the digital process to develop in a green direction.

Existing research has discussed the relationship between digital economy and green development from different perspectives. Although the effect of digital transformation on directly promoting the green development of firms has not been clearly determined, most scholars have a positive and optimistic attitude towards it. Digitalization and greening are both important directions of enterprise transformation, and they can develop in coordination. Digital transformation not only helps firms improve resource utilization efficiency and optimize energy management, but also may stimulate the potential of firms in green innovation, environmental protection technology and sustainable development, thus indirectly or directly promoting firms to assume more environmental responsibilities (Luo et al., 2023)[5]. By leading greening with digitalization and driving digitalization with greening, firms can realize the coordinated development of dualization and mutual promotion and integration. However, in the process of fulfilling environmental responsibility, some firms often adopt the strategy of impression management, which leads to the deviation between the disclosure information of environmental responsibility and the actual performance. This inconsistency has led to the phenomenon of " greenwashing " and " decoupling " to a certain extent (Parguel et al., 2011)[6]. This paper will focus on corporate environmental responsibility disclosure and corporate environmental responsibility performance, and investigate companies listed in Shanghai and Shenzhen A-shares from 2011 to 2024 to explore the impact and transmission mechanism of corporate digital technology innovation on corporate environmental responsibility.

2. Literature Review and Research Hypotheses

2.1. Literature Review

2.1.1. Digital Technology Innovation

At present, cutting-edge technologies such as big data, the Internet, blockchain, cloud computing, and artificial

intelligence have been widely promoted and applied across various industries and fields. Firms are rapidly advancing the process of digital transformation, and it is imperative to accelerate digital technology innovation.

Based on the specific application scenarios of digital technology innovation, the existing literature deeply studies the application process of enterprise digital technology in production and management, and explores the realization path of digital technology innovation by analyzing the high correlation factors affecting the development of digital technology (Hanelt et al., 2021)[7]. From an external perspective, external factors such as digital investment and policy support give firms more resources, which not only promotes the construction and improvement of digital infrastructure, but also accelerates the development of digital application scenarios (Ye et al., 2023)[8]. From an internal perspective, all the elements of an enterprise will have a profound impact on its technological innovation. For example, Tortora et al. (2021)[9] points out that dynamic knowledge capability can affect enterprise digital technology innovation from two dimensions of knowledge generation capability and knowledge acquisition capability, which helps firms to accumulate rich technical knowledge and experience, and provides a solid foundation for digital technology innovation.

Prior literature shows that digital technology innovation can support firm development by improving operational efficiency, strengthening resource integration, and affecting organizational performance (Khin et al., 2019)[10]. Some scholars have opened up new perspectives such as executive cognition, executive characteristic behavior, executive team heterogeneity and digital technology innovation (Firk et al., 2022)[11]. Scholars believe that the adoption of information and digital technology can not only reduce the cost of firms, improve the total factor productivity of firms, but also effectively improve the phenomenon of information asymmetry, thus strengthening the ability of firms to integrate resources, which is conducive to the realization of enterprise value (Svahn et al., 2017)[12].

2.1.2. Corporate Environmental Responsibility

As a major participant in economic activities, firms need to take the initiative to assume corresponding environmental responsibilities. Corporate environmental responsibility (CER) is an important part of corporate social responsibility. It refers to the responsibility of firms for ecological environment protection and social sustainable development while pursuing economic benefits (Minor and Morgan, 2011)[13]. Carrying out research on corporate environmental responsibility will help promote firms to pay more attention to environmental protection in production and operation, and promote the coordinated development of economy and environment.

Regarding the motivation of firms to assume environmental responsibility, the academic community generally conducts in-depth analysis from three dimensions : economic incentives, legitimacy motives, and altruistic feelings. First of all, economic incentive is one of the important driving forces for firms to undertake environmental responsibility. Corporate environmental responsibility is closely related to key factors such as corporate financial performance and market competitiveness. In order to meet the internal needs of their own sustainable development, firms have to attach great importance to green development, which is regarded as an important way to enhance core competitiveness and achieve long-term success (Li et al., 2020)[14]. Secondly, legitimacy motivation is also a factor that can not be ignored for firms to assume environmental responsibility. With the increasing global awareness of environmental protection, governments have strengthened the supervision of firms in environmental responsibility, and the media and the public have shifted their attention to the green behavior of firms (Pan et al., 2024)[15]. Even if some firms are subjectively unwilling to assume environmental responsibility, they have to put green development strategies on the agenda in the face of the expectations and requirements of external stakeholders (Cormier et al., 2004)[16]. Finally, altruism is another important motivation for firms to assume environmental responsibility. Some firms regard social responsibility as an important way to realize their own value. Driven by altruism, firms not only pay attention to their own economic interests, but also pay more attention to their positive impact on society and environment.

2.2. Research Hypotheses

2.2.1. Digital Technology Innovation and Corporate Environmental Responsibility

Under the background of globalization and sustainable development, corporate environmental responsibility has become an indispensable part of the comprehensive competitiveness evaluation system of firms. The existing research has different views on the relationship between environmental disclosure and environmental performance. Some scholars believe that firms that actively disclose environmental information usually pay more attention to environmental protection in actual production and operation. However, some scholars have found that firms will show opportunistic behavior tendencies when participating in environmental protection activities, and are more willing to disclose current situation descriptions and future planning information that are beneficial to their own image. There are even cases where the disclosure content does not match the actual environmental protection behavior (Mishra et al., 2016)[17]. So, how does digital technology innovation affect the disclosure and performance dimensions of CER? This question is an important topic for in-depth discussion and verification in this paper.

Digital technology innovation can reduce the greenwashing phenomenon of firms and promote firms to improve the quality of environmental information disclosure. On the one hand, digital technology innovation has greatly improved the accuracy and timeliness of information disclosure. The powerful data collection, processing and analysis capabilities of firms enable firms to more accurately record and track their environmental performance, thus providing more accurate environmental responsibility information disclosure and alleviating the information asymmetry between firms and the market (Liu et al., 2011)[18]. On the other hand, digital technology innovation improves the transparency and credibility of information disclosure and promotes the sharing of environmental information. In a low-level digital environment, external stakeholders are limited by the availability of information, and often can only rely on the information actively disclosed by the enterprise to evaluate and judge the enterprise. However, in the context of digital technology enabling information sharing, false or low-quality environmental information becomes easier to be exposed and screened, and the disclosure content of firms must tend to be objective. Cong and He (2019)[19] point out that digital technology

helps firms to establish standardized environmental management processes and reporting systems, making environmental information disclosure more standardized and unified. Accordingly, this paper proposes the following hypothesis.

H1a: Digital technology innovation reduces symbolic environmental disclosure.

Digital technology innovation can promote firms to attach importance to green development, and then improve the performance of firms to assume environmental responsibility. On the one hand, firms can make full use of digital technology innovation to achieve cost reduction and efficiency increase, and increase the vitality of firms. In the field of production, firms can optimize the production process through the deep integration of intelligent manufacturing, Internet of Things, big data and other technologies, so as to realize real-time monitoring of production data and efficient allocation of resources (Jabbour et al., 2018)[20]. The application of digital technology has also accelerated the development and promotion of green technology, and achieved a win-win situation of environmental and economic benefits (Dubey et al., 2019)[21]. In the field of management, digital technology can reduce the cost of communication between various departments within the enterprise and ensure the scientific formulation and effective implementation of environmental responsibility strategies (Gunasekaran et al., 2017)[22]. On the other hand, firms can innovate business models and open up new development patterns through digital technology innovation. Digital technology innovation has reshaped the values of firms and significantly enhanced their awareness of environmental responsibility. In today 's society, the public 's attention to environmental protection issues is increasing, and the fulfillment of corporate environmental responsibility has become an indispensable criterion for measuring the competitiveness of firms. In order to improve market competitiveness, firms need to embrace digital technology innovation, build an exchange model of environmental data and management experience shared with the government, industry associations, research institutions, etc., and promote the whole society to move towards a green, low-carbon and circular direction.

H1b: Digital technology innovation improves substantive environmental performance.

2.2.2. Digital Technology Innovation, Resource Acquisition, and Corporate Environmental Responsibility

Based on the resource-based view, resources are the cornerstone of the survival and development of firms, which directly determines whether firms can stand out in the fiercely competitive market. This paper will describe the relationship between digital technology innovation and CER from three resources: digital resources, knowledge resources and credit resources.

Obtaining digital resources is the basic requirement for firms to assume environmental responsibility. Digital resources are an organic combination of digital technology and data elements. They not only represent the latest achievements of information technology, but also are indispensable resources in the era of digital economy (Jones and Tonetti, 2020)[23]. Digital technology innovation is leading firms to continuously explore new ways to obtain digital resources, improve the utilization level of data elements, and inject strong impetus into enterprise development. With the continuous breakthrough of firms in the field of digital technology, the methods of data collection, processing and analysis have undergone earth-shaking changes (Bhandari et al., 2023)[24]. From the perspective of environmental information disclosure, digital resources provide great convenience for firms to prepare environmental responsibility reports. Through the integrated data acquisition and analysis system, firms can easily collect data on all aspects of production, operation and supply chain. These data not only provide an objective and accurate data source for the preparation of environmental responsibility reports, but also enhance the transparency and credibility of the report. From the perspective of environmental performance, the development of digital technology can help firms to establish a sharing mechanism, accelerate the exchange and cooperation of digital resources within the enterprise, and strengthen the exchange and sharing of internal and external information.

Obtaining knowledge resources is an effective way for firms to assume environmental responsibility. Firms can not only rely on previous technical experience and knowledge in a single technical field to achieve green development, but also need to continuously integrate knowledge from multiple technical fields. Digital technology has the function of integrating multi-domain technical knowledge. Its innovation is conducive to the integration and diversified development of knowledge, which not only improves the environmental protection ability of firms, but also stimulates the motivation of firms to assume environmental responsibility. Digital technology innovation helps firms obtain more effective knowledge resources from three aspects. First, it broadens the channels of knowledge acquisition. Digital technology innovation breaks the limitations of time and space and provides diversified knowledge resources for firms. Firms can quickly obtain the required knowledge and information through search engines, social media, industry reports and other channels (Kaplan and Vakili, 2015)[25]. Second, it improves the ability of knowledge extraction. Digital technology enables firms to deeply mine and analyze massive data and extract valuable information and knowledge from it (Lyytinen et al., 2016)[26]. Third, it promotes the integration of knowledge resources. With the help of digital tools, firms can integrate and share internal and external knowledge resources.

Obtaining credit resources is the key driving force for firms to assume environmental responsibility. The shortage of funds is the main factor restricting firms to actively fulfill their environmental responsibilities. Firms first need to face this problem in the process of green development. From the perspective of national policy inclination, China is promoting digital transformation with unprecedented efforts and deeply integrating this strategy with green development. In this context, firms' digital technology innovation is not only a positive action to comply with policy guidance, but also an effective way to improve access to credit resources. From the perspective of bank business operation, bank credit decision-making needs to examine the development prospects and profitability of firms, and technological innovation is one of the important considerations. Therefore, the digital technology innovation strength demonstrated by firms can not only significantly enhance their competitiveness in obtaining bank credit, but also transform credit resources into solid support for firms' green transformation and sustainable development. Based on the above analysis, this paper proposes the second research hypothesis.

H2: Digital technology innovation has a significant resource effect, which can promote firms to assume environmental responsibility by acquiring digital resources, knowledge resources and credit resources.

3. Research Design

3.1. Sample and Data

This paper uses annual panel data of A-share listed companies in Shanghai and Shenzhen from 2011 to 2024 for empirical analysis. The patent text data of listed firms related to digital technologies are obtained from the WinGo Financial Text Data Platform, while other raw data are sourced from the China Stock Market & Accounting Research Database and the Chinese Research Data Services Platform.

First, financial firms are excluded from the sample. Second, firms marked as ST or *ST as well as firms that were forcibly closed or delisted due to violations are removed. Third, firms in a state of debt crisis are excluded. Finally, firms with missing or abnormal data are removed. In order to avoid the negative impact of extreme values on the results, all continuous variables are winsorized at the 1% level.

3.2. Variable Selection

(1) Dependent Variable: Corporate Environmental Responsibility

This paper discusses CER from two dimensions: disclosure and performance. The degree of corporate environmental information disclosure mainly reflects the environmental information that firms actively communicate to external stakeholders. This paper selects 30 evaluation indicators of environmental information disclosure quality from seven aspects, including environmental management, environmental regulation and certification, and environmental performance and governance, and constructs the Word indicator based on the scores of these indicators. Specifically, the secondary indicators are first scored as follows: 0 points for no disclosure, 1 point for qualitative disclosure, and 2 points for quantitative disclosure. The scores are then summed with equal weights. Finally, the natural logarithm of the total score plus one is taken as the indicator of corporate environmental responsibility disclosure.

Table 1. Measurement of Environmental Responsibility Disclosure

Primary Indicator	Secondary Indicators
Environmental management	Environmental protection philosophy; environmental protection goals; environmental management system; environmental education and training; special environmental protection actions; environmental emergency response mechanism; environmental protection honors or awards; “three simultaneous” system
Environmental liabilities	Wastewater emissions; COD emissions; SO_2 emissions; CO_2 emissions; smoke and dust emissions; industrial solid waste generation
Environmental regulation and certification	Key pollution monitoring unit; pollutant discharge compliance; sudden environmental accidents; environmental violations; environmental petition events; ISO14001 certification; ISO9001 certification
Environmental performance and governance	Waste gas emission reduction and treatment; wastewater emission reduction and treatment; dust and smoke treatment; solid waste utilization and disposal; noise treatment; implementation of cleaner production
Carrier of environmental information disclosure	Annual reports; social responsibility reports; environmental reports

To ensure the objectivity of the measurement of corporate environmental performance, this paper uses third-party institutional data to measure firms’ environmental practices and selects the environmental performance score from Bloomberg ESG.

(2) Explanatory Variable: Digital Technology Innovation

In the era of Industry 4.0 and digital transformation, digital patent applications have become a representative indicator of firms’ digital innovation achievements. Existing studies have used the number of patent applications as a measure of corporate technological innovation, identifying patents related to digital technology fields based on the International Patent Classification (IPC) or the United States Patent Classification (USPC), thereby characterizing firms’ digital technology innovation activities.

Based on relevant literature and management practices, this paper conducts text analysis of patent applications and uses the number of digital patent applications as a quantitative indicator of firms’ digital innovation level. The specific procedure is as follows. First, keywords related to digital technology innovation are collected from relevant domestic information sources and policy documents, and a corresponding dictionary is constructed, including characteristic terms at two levels: “underlying technologies” and “technology applications.” Second, the specific text information of patent applications is obtained from the WinGo database, and keywords related to digital technology innovation are extracted through matching to determine whether each patent is a digital patent. Finally, through matching and counting, the number of digital patent applications of each firm in each year is calculated, and the natural logarithm of this value plus one is used as the measure of corporate digital technology innovation.

(3) Mediating Variables

① Data element level (Dig). This paper counts the frequency of detailed disclosures in firms’ annual financial reports regarding artificial intelligence technology, blockchain technology, cloud computing technology, big data technology, and the application level of digital technologies. The disclosure frequencies of all sub-items under these five indicators are then summed to measure the overall level of firms’ data elements.

② Knowledge expansion (Td). This paper uses the first four digits of IPC classification codes as the basis and takes the number of new knowledge fields involved in firms’ patents as a proxy for knowledge resources. If the knowledge fields associated with a firm’s patent applications in a given year did not appear in its patent application records over the previous five years, these patents are included in the measurement of knowledge expansion.

③ Credit misallocation (Fd). This paper introduces the level of financial mismatch burden as the measurement indicator. In essence, this indicator measures the deviation between a firm's cost of capital and the average cost of capital in its industry.

(4) Control Variables. Based on existing studies on digital technologies and CER, this paper selects the following firm-level characteristics as control variables: firm size (Size), leverage ratio (Lev), return on assets (ROA), proportion of fixed assets (Fixed), operating revenue growth rate (Growth), separation of ownership and control (Separate), CEO duality (Dual), proportion of independent directors (Indep), firm age (Age), and nature of ownership (SOE).

3.3. Baseline Regression and Model Specification

This paper adopts a fixed-effects model for empirical analysis. The model is specified in Equation (1), which is the baseline regression model of this paper. The explanatory variable is digital technology innovation (DT), while the dependent variables are corporate environmental responsibility disclosure (Word) and corporate environmental responsibility performance (Action).

$$Word(Action)_{i,t}=\beta_0+\beta_1 DT+\sum \beta_j Control_{i,t}+\sum Year+\sum Ind+\sum Region+\varepsilon_{it} \quad (1)$$

4. Empirical Results and Analysis

4.1. Descriptive Statistics

The mean value of digital technology innovation is 0.12, with a standard deviation of 0.51, a maximum value of 6.09, and a minimum value of 0.00. This indicates, on the one hand, that the market has attached increasing importance to digital technology innovation, and, on the other hand, that there remain substantial differences in the level of digital technology innovation across firms, suggesting considerable room for improvement. The mean values of corporate environmental responsibility disclosure and environmental responsibility performance are 2.36 and 0.71, respectively, indicating that some firms have begun to improve their environmental responsibility practices in recent years.

Table 2. Descriptive Statistics

Variable	(1) N	(2) Mean	(3) Std.	(4) Min	(5) Max	(6) Median
Word	14,239	2.36	0.71	0.00	3.95	2.30
Action	20,346	0.71	1.17	0.00	4.35	0.00
DT	20,346	0.12	0.51	0.00	6.09	0.00
Dig	20,346	1.40	1.41	0.00	6.31	1.10
Td	20,346	1.50	1.21	0.00	6.79	1.61
Fd	20,346	0.11	0.84	-1.00	3.35	0.04
Lev	20,346	0.47	0.20	0.01	1.00	0.47
ROA	20,346	0.03	0.08	-1.86	0.82	0.03
Fixed	20,346	0.22	0.17	0.00	0.97	0.18
Growth	20,346	0.14	0.42	-2.73	4.88	0.09
Seperate	20,346	5.09	7.97	-80.58	60.32	0.00
Dual	20,346	0.22	0.41	0.00	1.00	0.00
Indep	20,346	37.55	5.69	16.67	80.00	36.36
Age	20,346	2.60	0.46	0.70	3.47	2.64
SOE	20,346	0.47	0.50	0.00	1.00	0.00

4.2. Model Results and Hypothesis Testing

Based on the specification of regression model (1), this paper examines the effects of digital technology innovation (DT) on the disclosure and performance dimensions of CER, respectively. First, Column (1) of Table 3 reports the direct effect of digital technology innovation on corporate environmental information disclosure without including any control variables. The results show that digital technology innovation has a negative and significant effect at the 1% significance level, indicating that digital technology innovation reduces symbolic environmental disclosure. Similarly, Column (2) shows the positive effect of digital technology innovation on corporate environmental performance. Columns (3) and (4) include control variables, and the effects of digital technology innovation remain significant, thereby verifying Hypothesis 1.

Table 3. Baseline Regression Results

Variable	(1) Word	(2) Action	(3) Word	(4) Action
DT	-0.037***	0.087***	-0.038***	0.089***
	(-3.08)	(3.50)	(-3.14)	(3.56)
Constant	2.069***	0.542*	1.905***	1.666***
	(10.22)	(1.68)	(7.32)	(3.81)
Controls	No	No	Yes	Yes
Year/Ind/Region	Yes	Yes	Yes	Yes
Observations	14,239	20,346	14,239	20,346
Adjusted R^2	0.220	0.190	0.221	0.195

Notes: t-statistics are reported in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively. The same applies to the following tables.

4.3. Mechanism Test

Based on the preceding analysis, this paper argues that digital technology innovation may encourage firms to actively assume environmental responsibility through the catalytic effect of resource acquisition. Accordingly, the following model is constructed:

$$Med_{i,t}=\alpha_0+\alpha_1 DT+\sum \alpha_j Control_{i,t}+\sum Year+\sum Ind+\sum Region+\varepsilon_{it} \quad (2)$$

This paper conducts a mediation effect test based on the model specifications shown in Equations (1) and (2). First, the mediating mechanism for obtaining digital resources is tested. In this paper, the level of data elements is used as a proxy for firms' digital resources. The higher the level of data elements, the richer the digital resources mastered by firms. The regression results of Table 4 show that this effect is significantly positive and highly significant at the statistical level of 1%. Second, the mediating mechanism of acquiring knowledge resources is tested. As shown in Table 4, digital technology innovation has significantly promoted the acquisition of knowledge resources, and this positive impact has also been verified at the statistical level of 1%. Thirdly, the mediating mechanism of improving financial mismatch is tested. The results show that digital technology innovation has significantly reduced the degree of corporate credit mismatch and passed the 1% significance test, indicating that digital technology innovation has played a positive role in optimizing the allocation of credit resources and meeting the capital needs of firms. On the whole, digital technology innovation can obtain the benefits of green development of firms by enhancing the acquisition effect of digital resources, knowledge resources and credit resources, which greatly promotes the practical actions of firms to fulfill their environmental responsibilities.

Table 4. Mechanism Test Results

Panel A: Mediation Tests for Environmental Responsibility Disclosure			
Variable	Dig	Td	Fd
	(1)	(2)	(3)
DT	0.573***	0.324***	-0.089***
	(31.95)	(21.22)	(-7.98)
Constant	1.877***	1.345***	-0.384***
	(21.63)	(15.50)	(-6.08)
Controls	Yes	Yes	Yes
Year/Ind/Region	Yes	Yes	Yes
Sobel z-statistic	-9.987***	-8.005***	-3.882***
Observations	14,239	14,239	14,239
Adjusted R^2	0.451	0.234	0.131
Panel B: Mediation Tests for Environmental Responsibility Performance			
Variable	Dig	Td	Fd
	(1)	(2)	(3)
DT	0.552***	0.322***	-0.092***
	(33.42)	(23.26)	(-9.14)
Constant	1.715***	1.316***	-0.380***
	(22.96)	(17.70)	(-7.00)
Controls	Yes	Yes	Yes
Year/Ind/Region	Yes	Yes	Yes
Sobel z-statistic	8.825***	20.643***	3.524***
Observations	20,346	20,346	20,346
Adjusted R^2	0.440	0.228	0.125

4.4. Endogeneity and Robustness Tests

(1) Instrumental Variable Method (2SLS)

In this paper, two instrumental variables are selected and the regression results are tested by two-stage regression method. The first instrumental variable is the number of broadband accesses, and the second is the minimum distance between the city centroid and backbone cities of the optical cable network. The results in Table 5 show that regions with a larger number of broadband accesses have higher levels of digital technology innovation, while firms located farther away from backbone cities of the optical cable network tend to have lower levels of digital technology innovation. After adding instrumental variables, the impact of digital technology innovation on corporate environmental disclosure and corporate environmental performance is still significant. This paper tests the instrumental variables. The Anderson LM statistic is significant at the 1% level, rejecting the null hypothesis of insufficient instrumental variable identification. The Cragg-Donald Wald F statistic is greater than the critical value of the weak instrumental variable identification F-test at the 10% significance level, rejecting the null hypothesis of weak instrumental variables.

Table 5. Instrumental Variable Estimation

Variable	First Stage	Second Stage	First Stage	Second Stage	First Stage	Second Stage	First Stage	Second Stage
	DT	Word	DT	Action	DT	Word	DT	Action
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
iv1	0.210***		0.182***					
	(6.90)		(7.42)					
iv2					-0.435***		-0.361***	
					(-6.83)		(-7.37)	
DT		-0.610***		0.531***		-0.382*		1.177***
		(-2.95)		(6.81)		(-1.94)		(3.71)
Constant	-0.336***	1.429***	-0.277***	-1.266***	-0.194***	1.475***	-0.144***	-1.267***
	(-4.98)	(14.25)	(-5.60)	(-10.41)	(-3.01)	(15.52)	(-3.05)	(-10.43)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year/Ind/Region	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	14,239	14,239	20,346	20,346	14,239	14,239	20,346	20,346
Anderson LM		47.651		55.079		46.728		54.413
Cragg-Donald Wald F		47.579		55.041		46.654		54.374

(2) Alternative Variable Measurements

First, the measurement of digital technology innovation is replaced. This paper constructs a correspondence among "digital economy core industry classification codes - four-digit national economic industry classification codes (SIC4) - IPC subgroups." This correspondence identifies the specific technological fields involved in digital technology innovation and maps them to the corresponding IPC codes, thereby accurately identifying patents related to digital technology innovation applied for by firms. The selected digital technology innovation invention patents are then aggregated and used as an alternative measure of digital technology innovation. Columns (1) and (2) of Table 6 show that, after replacing the measurement of digital technology innovation, the promoting effect of digital technology innovation on CER remains significant, further supporting the conclusion of Hypothesis 1.

Second, the measurement of CER is replaced. For the "word" of CER, this paper uses social responsibility reports as the basis for the alternative measurement. Word_A represents a dummy variable for environmental information disclosure, which equals 1 if the listed firm discloses environmental information in its annual social responsibility report in that year, and 0 otherwise. For the "action" of CER, the environmental rating score from Huazheng ESG is used as an alternative variable. Columns (3) and (4) of Table 6 show that, after replacing the measurement of the dependent variables, the relationship proposed in Hypothesis 1 remains unchanged.

(3) Replace the Research Sample

From the perspective of spatial location, firms in the four municipalities of China may have natural advantages in acquiring digital technology innovation capabilities. This location heterogeneity or the robustness of the benchmark regression results constitute potential interference. Therefore, this paper excludes the observations of listed companies in Beijing, Shanghai, Tianjin and Chongqing, and re-estimates the main regression model based on the adjusted samples. From the perspective of time node, 2015 is the key node for the rapid development of digital technology in China. Since then, digital technology innovation has ushered in a new round of growth opportunities. Therefore, this paper excludes the samples before 2015 and regresses again. The estimation results in columns (5) to (8) of Table 6 show that the conclusions of the study have not changed after excluding some of the above samples.

Table 6. Robustness Test Results

Variable	Alternative Variable Measurements				Replace the Research Sample			
	Word	Action	Word_A	Action_A	Word	Action	Word	Action
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
DT			-0.029***	0.331***	-0.023*	0.295***	-0.023**	0.299***
			(-5.89)	(13.83)	(-1.80)	(13.43)	(-1.97)	(15.46)
DT_A	-0.013***	0.100***						
	(-4.94)	(7.43)						
Constant	2.236***	-1.029***	-0.003	1.676***	2.258***	-0.816***	2.338***	-1.241***
	(41.01)	(-13.89)	(-0.10)	(21.55)	(37.91)	(-10.09)	(39.56)	(-14.31)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year/Ind/Region	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	14,239	20,346	14,918	20,346	11,740	16,323	11,315	15,231
Adjusted R^2	0.096	0.178	0.031	0.116	0.098	0.1587	0.058	0.189

5. Further Discussion

5.1. Heterogeneity Analysis

5.1.1. Slack Resources

To examine the heterogeneous effect of slack resources, this paper uses the ratio of total liabilities to total owners' equity, namely the equity ratio, to measure corporate slack resources (Slack). The full sample is then divided into a high-slack-resource group and a low-slack-resource group based on the annual industry median of slack resources, and group regressions are conducted. The results are reported in Table 7.

In the high-slack-resource group, digital technology innovation significantly promotes firms to "say less" and "do more" in terms of environmental responsibility. In contrast, in

the low-slack-resource group, digital technology innovation does not significantly restrain excessive environmental responsibility disclosure; instead, it shows an insignificant positive correlation with environmental disclosure. Columns (3) and (4) indicate that digital technology innovation has a positive effect on corporate environmental responsibility performance under different levels of slack resources. However, the regression coefficient of digital technology innovation in the high-slack-resource group is notably larger than that in the low-slack-resource group. Furthermore, this paper conducts a bdiff test, and the results show that the regression coefficients differ significantly between the two groups. The above analysis suggests that, in promoting firms' fulfillment of environmental responsibility, the positive effect of digital technology innovation is more pronounced when firms have higher levels of slack resources.

Table 7. Heterogeneity Results by Slack Resources

Variable	High Slack Word	Low Slack Word	High Slack Action	Low Slack Action
	(1)	(2)	(3)	(4)
DT	-0.039***	0.000	0.336***	0.195***
	(-2.96)	(0.02)	(15.18)	(6.17)
Constant	2.114***	2.432***	-0.957***	-0.817***
	(24.55)	(31.77)	(-8.06)	(-8.37)
Controls	Yes	Yes	Yes	Yes
Year/Ind/Region	Yes	Yes	Yes	Yes
Observations	7,007	7,230	10,158	10,187
Adjusted R^2	0.105	0.108	0.195	0.167

5.1.2. Environmental Regulation

This paper uses emission costs to measure the degree of environmental regulation, and explores the differences between digital technology innovation and CER under different levels of environmental constraints. After obtaining the data of pollution charges through annual environmental reports and financial statements, this paper uses the method of business income standardization to measure them, and finally divides them into high environmental regulation group and low environmental regulation group. The results of Table 8 show that digital technology innovation has a weak impact on firms with less environmental regulation. This may be because environmental regulation has a forced effect, which can encourage firms to protect the environment.

Table 8. Heterogeneity Results by Environmental Regulation

Variable	High Regulation Word	Low Regulation Word	High Regulation Action	Low Regulation Action
	(1)	(2)	(3)	(4)
DT	-0.036***	0.002	0.304***	0.265***
	(-2.71)	(0.12)	(12.51)	(9.56)
Constant	2.329***	2.113***	-1.505***	-0.507***
	(30.75)	(26.45)	(-13.72)	(-5.21)
Controls	Yes	Yes	Yes	Yes
Year/Ind/Region	Yes	Yes	Yes	Yes
Observations	7,554	6,682	10,172	10,173
Adjusted R^2	0.134	0.101	0.211	0.165

5.2. The Breadth and Depth of Digital Technology

This paper argues that the breadth and depth of digital technology applications represent the horizontal coverage dimension and vertical dimension of corporate digital technology, which will have an important impact on CER.

The breadth of digital technology applications reflects the types and combinations of digital technologies applied by firms, and reflects the diversity and cross-border nature of digital technologies. The application depth of digital technology reflects the familiarity of firms in applying digital technology, and reflects the permeability and professionalism of digital technology. On this basis, this paper uses the number of types of digital application keywords in the annual report to measure the breadth of digital technology applications, which is recorded as DT_Breadth ; the natural logarithm of the frequency of key words related to the use of digital technology in the annual report is used to measure the strength of digital technology application, which is recorded as DT_Depth. Keywords related to digital technology development include data mining, text mining, data visualization, heterogeneous data, etc. Keywords related to the application of digital technology include data management, data network, data platform, digital finance and so on. The results in Table 9 show that the breadth and depth of digital technology significantly promote corporate environmental responsibility at different levels, which is consistent with the point of view proposed in Hypothesis 1, and further verifies the correctness of the conclusions of this paper.

Table 9. Breadth and Depth of Digital Technology

Variable	Word	Word	Action	Action
	(1)	(2)	(3)	(4)
DT_Breadth	-0.009**		0.141***	
	(-2.12)		(18.62)	
DT_Depth		-0.001*		0.002***
		(-1.71)		(4.52)
Constant	2.239***	2.237***	-1.050***	-1.045***
	(41.08)	(41.04)	(-14.35)	(-14.07)
Controls	Yes	Yes	Yes	Yes
Year/Ind/Region	Yes	Yes	Yes	Yes
Observations	14,239	14,239	20,346	20,336
Adjusted R^2	0.095	0.095	0.189	0.170

6. Conclusions and Policy Implications

Using A-share listed companies in Shanghai and Shenzhen from 2011 to 2024 as the research sample, this paper examines the impact of corporate digital technology innovation on the "word" and "action" of environmental responsibility. The findings are as follows. First, digital technology innovation significantly improves corporate environmental responsibility performance. It not only reduces symbolic environmental disclosure but also improves substantive environmental responsibility performance. Second, digital technology innovation has a resource effect. Firms can improve their fulfillment of environmental responsibility by acquiring digital resources, knowledge resources, and credit resources. Third, the environmental governance effect of digital technology innovation is heterogeneous. It is more pronounced among firms with higher levels of slack resources and firms subject to stronger environmental regulation. Fourth, from the perspective of the breadth and depth of digital technology application, both dimensions can promote firms to better assume environmental responsibility at different levels.

The findings of this paper provide several practical implications. For firms, they should actively promote the application of digital technologies such as big data, cloud computing, the Internet of Things, and artificial intelligence, optimize resource allocation, production processes, and supply chain management, and reduce resource consumption and pollutant emissions. At the same time, firms should incorporate environmental responsibility into corporate strategy and daily operations, improve environmental performance evaluation systems, and promote green technology research and development as well as cooperation.

For governments, it is necessary to further improve the policy system that supports digital technology innovation and the fulfillment of CER. Governments can encourage firms' green transformation through tax incentives, fiscal subsidies, green finance, and other policy tools. Meanwhile, environmental laws, regulations, and regulatory mechanisms should be strengthened, and greater constraints should be imposed on illegal pollution discharge and resource waste. In addition, governments should promote the deep integration of digital technologies and environmental governance, build public service platforms, improve standards and certification systems for green digital technologies, and strengthen international cooperation to jointly address climate change and environmental governance challenges.

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