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Digital Transformation on Corporate Environmental Performance

Yuan Tian, Shimin Song, Jin Ma

School of Accounting, Anhui University of Finance and Economics, Bengbu, Anhui 233030, China

Abstract: Digital transformation, as a powerful catalyst for the deep integration of the digital economy and the real economy, has emerged as a crucial driver for enterprise transformation and upgrading, as well as reshaping the competitive landscape. Drawing on data from Chinese A-share listed companies between 2010 and 2019, this study empirically examines the relationship between digital transformation and corporate environmental performance, as well as its underlying impact mechanisms. The findings indicate that digital transformation significantly enhances the level of corporate environmental performance. Moreover, corporate digital transformation facilitates the improvement of environmental performance by enhancing green technology innovation capabilities and optimizing production structures. The positive impact on environmental performance is particularly pronounced in state-owned enterprises, high-growth companies, those with substantial research and development investments, and those garnering high analyst attention.

Keywords: Digital transformation, Environmental performance, Green technology innovation, "Dual carbon" goal.

1. Introduction

At present, with the rapid development of China's economy, negative impacts such as ecological environmental pollution and excessive energy consumption have increasingly burdened the self-purification capacity of ecosystems, contradicting the concept of green development advocated by the country. China is striving to achieve "harmonious coexistence" and a sustainable development strategy. To achieve the "dual carbon" goal officially proposed at the 75th session of the United Nations General Assembly, General Secretary Xi Jinping emphasized at the leaders' climate summit the need to comprehensively guide economic and social development towards green transformation, with a focus on green and low-carbon energy development. The 20th National Congress of China reiterated the importance of promoting green and low-carbon economic and social development as the key to achieving high-quality development. Enterprises, as the "lifeblood" of economic development and the main source of energy consumption and carbon emissions, must prioritize sustainable development, improve environmental performance, and give equal importance to economic development and environmental protection. Enhancing environmental performance has become an urgent and ongoing task in environmental protection.

With the continuous optimization and iteration of digital technology, the integration of digital technology and physical enterprises is accelerating, leading to profound changes in all aspects of the value creation process. According to the "White Paper on China's Digital Economy Development (2022)," China's digital economy has been growing at an average annual rate of 15.9% since 2021, surpassing the average GDP growth rate during the same period. The digital economy has reached a scale of 45.5 trillion yuan, with a year-on-year nominal increase of 16.2%, and industrial digitization has become the primary driving force behind its development. The digital economy, as a new driving force for future economic growth (Peng Gang, Zhao He, & Zhao Lexin, 2020) [13], provides inexhaustible momentum for improving the production efficiency of enterprises (Zhao Chenyu et al., 2021) [14]. In China' "14th Five-Year Plan" and the 2035 long-term goal outline, elements such as the digital economy are identified as key pillars to achieve carbon neutrality, and the digital application of the manufacturing process is being further deepened. Therefore, driven by policies, the successful resolution of the potential conflicts between digital transformation, corporate development, and pollution becomes crucial for promoting the high-quality development of enterprises.

The "2022 Chinese Enterprise Digital Transformation Index" released by Accenture shows that the score for the digital transformation of Chinese enterprises in 2022 remained above 50 after breaking through 50 in 2021. This indicates that digital transformation is continuously progressing, and its implementation effects have garnered significant attention from scholars. However, existing research on the digital transformation of enterprises predominantly focuses on its economic consequences (Jin Yu et al., 2022) [15], primarily concerning economic performance and corporate governance, while lacking an in-depth exploration of the connection between digital transformation and environmental performance. Therefore, the impact of digital transformation on corporate environmental performance as a new driver of economic development, as well as the potential mechanisms involved, requires comprehensive investigation. An in-depth examination of these issues can establish a solid theoretical foundation for the vigorous development of China's digital economy and provide crucial empirical evidence for achieving the "dual carbon" goal.

2. Literature Review and Research Hypotheses

2.1. Literature Review

2.1.1. Research on the Economic Consequences of Digital Transformation

Digital transformation, at its core, involves the integration of emerging digital technologies with physical enterprises. By introducing digital technologies into existing corporate management structures, it brings about changes in strategic thinking, business models, and the optimization of production factor allocation, thereby driving more precise, intelligent, and efficient business processes, production methods, and management approaches. This transformation enables enterprises to undergo a disruptive change process from the "industrialized management mode" to the "digital management mode." Existing studies have predominantly focused on the economic consequences of digital transformation and have conducted in-depth discussions on its impact on corporate performance and corporate governance.

From the perspective of corporate financial performance, previous studies have found that digital transformation can enhance resource allocation efficiency and significantly improve operational efficiency across various company processes (Karim and Rivard, 2019) [1]. Additionally, by improving information transparency, it can effectively alleviate financing difficulties, reduce real earnings management behaviors (Luo Jinhui and Wu Yilong, 2021) [16], and enhance corporate value (Dasilva, 2018; Yuan Zeming et al., 2022; Chen Zhongfei et al., 2022; Guan Kao Lei and Zhu Haining, 2022) [2, 17-19]. Digital transformation can also strengthen enterprises' investment capabilities (Deng Bo, 2022) [20] and promote their upgrade by stimulating innovation momentum, improving internal control quality, and increasing production capacity utilization (Han Guogao et al., 2022; Du Yong and Lou Jing, 2022) [21-22]. Furthermore, it contributes to enhancing total factor productivity (Mikalef and Pateli, 2017; Yuan Chun et al., 2021) [3, 23].

Simultaneously, digital transformation can improve non-economic performance within enterprises and generate significant social spillover effects. Existing research indicates that digitalization, by alleviating environmental information constraints, has a dual effect of "incremental improvement" on corporate green innovation performance (Jones and Tonetti, 2020; Xiao Jing and Zeng Ping, 2022; Shen Minghao and Tan Weijie, 2022) [4, 24-25]. This improvement extends to corporate social responsibility performance (Liakhovych et al., 2021; Shen Minghao et al., 2022) [5, 26].

Regarding corporate governance, previous studies have found that digital transformation enhances the ability to curb the hollowing out behavior of major shareholders (Yao Youfu, 2022) [27], improves stakeholder supervision, and reduces the extent of unreasonable decision-making behavior by managers. This improvement promotes enhanced corporate governance, mitigating the second type of agency conflict between major and small to medium shareholders (Ge et al., 2021; Qi Huaijin et al., 2020) [6, 28]. Digital transformation also reduces internal earnings management, increases the attention of external analysts (Li Wei, 2022) [29], and consequently reduces stock price synchronicity, thereby protecting stakeholder interests. Moreover, it improves auditors' audit efficiency and the overall level of governance, resulting in reduced audit fees for corporate financial statements (Zhang Yongshen et al., 2021) [30].

2.1.2. Factors Influencing Environmental Performance

Environmental performance refers to the outcomes achieved by enterprises in addressing external environmental challenges based on the goals of sustainable development and stakeholder wealth maximization. Existing research primarily examines the influence of internal and external factors on corporate environmental performance.

Internal factors play a significant role. From the perspective of corporate governance, the nature of equity in state-owned enterprises, a larger board of directors, and a separation of powers between the chairman and the general manager can significantly promote the level of corporate environmental performance (Ye Chengang et al., 2016) [31]. An internationalized board of directors can enhance the environmental performance of enterprises by strengthening their moral and strategic motivations to undertake environmental responsibilities (Du Xingqiang et al., 2021) [32]. The characteristics of executives are also closely related to corporate environmental performance. Companies with female executives and those implementing effective executive compensation incentives exhibit better environmental performance (Menguc et al., 2010; Wu Dejun and Huang Dandan, 2013; Chang Yuan et al., 2022) [7, 33-34]. Furthermore, the decision-making of management and shareholders influences the environmental actions of enterprises, and a high level of corporate governance promotes the improvement of environmental performance (Ramus and Steger, 2000) [8]. In terms of corporate behavior, activities such as mergers and acquisitions (M&A) and green M&A (Wang Wei et al., 2022; Wang Wenhua and Shen Jiamin, 2022) [35-36], export behavior (Cui et al., 2016; Richter and Schiersch, 2017) [9-10], industrial transformation (Fan Weijie, 2020) [37], increased environmental investment (Yiliqi et al., 2021) [38], strengthened corporate environmental management control (Li Zhibin et al., 2022) [39], and the implementation of new environmental strategies by enterprises (Wang Liping et al., 2021) [40], all contribute to the continuous improvement of environmental performance.

External factors also play a crucial role. Policies such as "Energy Saving and Low Carbon," the "Environmental Protection Law," environmental regulations, and green credit policies significantly improve corporate environmental performance (Che Shuai, 2022; Pan Hongbo and Rao Xiaoqiong, 2019; Wang Bing et al., 2017; Xiao Jianzhong and Dong Yuxuan, 2023) [41-44]. Additionally, environmental subsidies (Wang Xingfen and Zheng Jia, 2020) [45], environmental law enforcement supervision (Shen Hongtao and Zhou Yankun, 2017) [46], government environmental auditing (Yu Lianchao et al., 2020) [47], media attention resulting from foreign shareholding (Sun Fangcheng et al., 2021) [48], government scale (Bye and Klemetsen, 2018) [11], and market environment (Duanmu et al., 2018) [12] all positively influence and supervise corporate environmental performance.

By reviewing the existing literature, it becomes evident that previous studies have primarily focused on the impact of corporate digital transformation on financial performance and corporate governance, with limited exploration of the link between digital transformation and environmental performance. Therefore, it is necessary to conduct a comprehensive investigation to determine whether the digital transformation of enterprises affects their environmental performance and to identify the underlying mechanisms.

2.2. Research Hypothesis

The digital economy encompasses cross-border integration, innovation-driven approaches, structural reshaping, and the Internet of Everything. These aspects bring about changes in the management models of enterprises, improve the level of green technology innovation, optimize production structures, and promote the enhancement of corporate environmental performance. The main reasons are as follows:

Firstly, digital transformation encompasses processes such as information collection, data collation and analysis, and real-time feedback. This facilitates the efficient allocation of enterprise resources, thereby promoting continuous innovation behavior, including green technology innovation within enterprises (Zhou Xuefeng et al., 2022) [49], which ultimately improves corporate environmental performance. Specifically, digital transformation has given rise to a networked collaborative innovation ecosystem. By establishing a digital R&D platform that fosters open innovation, enterprises can better gather, integrate, and connect elements and resources such as data, technology, talent, and capital, thus promoting knowledge sharing. This stimulates the vitality of green innovation (Liu Chang et al., 2022) [50]. Additionally, digital transformation utilizes vast data resources to drive innovation paradigm shifts. Through comprehensive and timely access to key information such as policy guidance, market demand, and new technological development opportunities, enterprises can stimulate innovative thinking, reduce innovation sunk costs and failure risks, and optimize the innovation process (Sun Guofeng et al., 2022) [51]. This expedites the exploration and research and development processes of key green technologies, ultimately enhancing the level of green technology innovation. Lastly, successful digital transformation attracts media attention, resulting in positive publicity and the propagation of digital transformation strategies' advantages and achievements within society. This helps enterprises establish a positive image, increase public recognition, and motivate ongoing investment in green technology innovation (Zhang Yuming et al., 2021) [52]. The improvement in the level of green technology innovation can lead to the production of easily recyclable or regenerative products, reduction in product environmental load, and decreased or eliminated environmental pollution. Additionally, through green process innovation, clean production technology and terminal treatment technology can be employed to achieve source control and end treatment of environmental pollution, significantly promoting the enhancement of corporate environmental performance (Li Wanhong and Li Na, 2023; Luo Enyi, 2020) [53-54].

Secondly, digital transformation improves the level of environmental performance by facilitating structural optimization of the production and operation processes. Informatization and digitalization enable enterprises to make accurate predictions based on market information in advance. When faced with subsequent shocks, enterprises can swiftly respond and adjust, optimizing the structural flexibility of their production and operation processes. This reduces resource waste and achieves energy savings and emission reductions during production (Wang Yongjin, 2017) [55]. Simultaneously, digital transformation impacts the production, supply, sales, and all links within the upstream and downstream industrial chains of enterprises. This helps enterprises reorganize their production and operation processes and optimize the structure of various departments, thereby improving resource utilization efficiency and reducing emissions of various pollutants (Shi Dan, 2018) [56].

Based on the above, this paper proposes Hypothesis H: Under unchanged conditions, digital transformation can improve the level of corporate environmental performance.

3. Research Design

3.1. Sample Selection and Data Source

In this study, listed companies from 2010 to 2019 are selected as research samples, and the following screening criteria are applied to the samples: (1) Exclusion of ST and PT listed companies, (2) Exclusion of companies with abnormal financial data, (3) Exclusion of companies with missing relevant data, and (4) Winsorization of all continuous variables at the 1st and 99th percentiles. Finally, 2148 observations are obtained. The data sources for this study are as follows: the digital transformation index is derived from text analysis of the annual reports of listed companies, sewage charge data is obtained from the disclosure of company's annual reports, and other financial data are sourced from the CSMER Guotaian database.

3.2. Variable Definition

3.2.1. Explained variables

This study follows the methodology outlined in the literature (Yi Liqi et al., 2021) [57] and employs the ecological benefit method to assess the environmental performance of enterprises, which represents the operational outcomes resulting from the enterprise's environmental impact. A higher index value indicates a better environmental performance of the enterprise. The operational outcomes are measured by the total operating income, while the environmental impact is reflected by the sewage charge. The sewage charge is a tax imposed on enterprises by the government in response to the discharge of harmful pollutants, providing a comprehensive and objective reflection of the enterprise's environmental pollution status.

3.2.2. Explanatory variables

Referring to the research conducted by Wu Fei et al. (2021) [58], this paper calculates the digital transformation (DT) level of enterprises using a text mining approach. The specific steps are as follows: Firstly, the annual report of the enterprise is collected and converted into text format. Secondly, two levels, namely "underlying technology application" and "technical practice application," are identified as the key areas of enterprise digital transformation. The "underlying technology application" level focuses on specific applications of digital technologies, while the "technical practice application" level pertains to the implementation of digital technologies in business scenarios such as informatization, intelligent manufacturing, and Internet business models. Building on existing literature, additional keywords are incorporated to establish a keyword map for enterprise digital transformation. Thirdly, using Python programs, the occurrence of digital transformation keywords in corporate annual reports is captured. Lastly, a digital transformation index is constructed. Since the frequency of characteristic words typically exhibits a "right-biased" distribution and to mitigate the impact of 0 occurrences, a logarithmic transformation is applied after adding 1 to the frequencies.

Table 1. Variable names and calculation methods

Variable type	Variable name	Variable symbol	Variable meaning
Explained variable	Environmental performance	EP	Ln (operating income/sewage discharge fee)
Explanatory variables	Digital transformation	DT	Enterprise digital transformation index constructed by text analysis method
Control variable	Financial leverage	Lev	Ratio of total liabilities to total assets
	Enterprise size	Size	The natural logarithm of total assets at the end of the period
	Total asset turnover	Tat	Growth ratio of total asset balance at the end of the current year compared with the previous year
	Proportion of monetary funds	Cash	Ratio of monetary funds to total assets
	Return on assets	Roa	Ratio of corporate net profit to total assets
	Institutional holding	InsHoldper	The sum of the shareholding ratios of institutional investors percentage
	Dual job	Dual	If the general manager is also the chairman, then Dual=1, otherwise Dual=0
	Board independence	Ind	The ratio of the number of independent directors to the total number of board members
	Nature of property rights	SOE	State-owned enterprises take 1, otherwise take 0
	Annual effect	Year	Year dummy variable
	Industry effect	Industry	Industry dummy variable

3.2.3. Control variables

Lev, Size, Tat, Cash, Roa, InsHoldper, Dual, Ind, SOE as control variables in the model, and controls the industry and year effects. All variable definitions and calculation methods are shown in Table 1.

3.3. Model Construction

To examine the positive correlation between digital transformation and corporate environmental performance, we constructed Model (1) for testing purposes. If α1 is significantly positive, it indicates a positive correlation between digital transformation and corporate environmental performance.

$$EP_{i,t} = \alpha_0 + \alpha_1 DT_{i,t} + \alpha_2 Control_{i,t} + \sum Year + \sum Industry + \varepsilon_{i,t} \quad (1)$$

4. Demonstration Results and Analysis

4.1. Basic Regression Analysis

Table 2 presents the regression analysis results of digital transformation and corporate environmental performance. From Table 2, it can be observed that the adjusted R-squared value is 0.2366, indicating a satisfactory model fit. The regression coefficient of digital transformation (DT) on enterprise environmental performance (EP) is 0.087, and the relationship between the two variables is significant at the 5% level. This suggests a significant positive correlation between digital transformation and the level of enterprise environmental performance, providing support for the verification of hypothesis H.

Table 2. Regression analysis of digital transformation and corporate environmental performance

Variable	EP
DT	0.0877^{**}
	(1.9865)
Controls	yes
year	control
Industry	control
Constant	3.9765^{***}
	(5.2202)
Number of samples	2148
Adjusted R^2	0.2366

4.2. Robustness Test

The robustness test is conducted by changing the measurement method of the explained variable, altering the sample size, and performing an endogeneity test.

4.2.1. Changing the method of measuring the explained variables

To strengthen the research findings, this study modifies the measurement method of corporate environmental performance to the environmental protection expenditure rate and employs the updated explained variables for regression analysis. The results of the regression analysis are presented in column (1) of Table 3. The coefficient of DT is -0.1229, indicating that digital transformation can reduce the environmental protection expenditure rate of heavy enterprises. This demonstrates a significant positive correlation between digital transformation and corporate environmental performance.

4.2.2. Changing the sample size

The sample is adjusted, starting from 2011, and the regression analysis is conducted once again. The results are displayed in column (2) of Table 3. The coefficient of digital transformation (DT) and environmental performance (EP) are significantly positive at the 10% level, supporting the previous conclusion.

4.2.3. Endogeneity test

Given that digital transformation may impact firm environmental performance, there is an inherent issue of causality, implying that firms with better environmental performance are more motivated to undertake digital transformation. To ensure the reliability of the research results, this study employs the instrumental variable method for a robustness test. Two instrumental variables are chosen: the mean value DT_IV1 of the level of digital transformation (DT) and the lagged one-period DT_IV2 of the level of digital transformation (DT). Table 3 presents the estimated results of the instrumental variable method. The coefficients of DT_IV1 and DT_IV2 in column (3) are significantly positive at the 1% level. Column (4) represents the second-stage regression results, with the coefficients of DT being significantly positive at the 1% level, thereby confirming the findings of this study.

Table 3. Robustness check

Changing method of measuring the explained variable		Changing sample size	Endogeneity test	
	(1)	(2)	(3)	(4)
Variable	Epe	EP	EP	EP
DT	-0.1229***	0.0860*		0.1747***
	(-2.8561)	(1.8993)		(2.5823)
DT_IV1			0.4794***	
			(5.0520)	
DT_IV2			0.7562***	
			(34.6503)	
Controls	yes	yes	yes	yes
year	control	control	control	control
Industry	control	control	control	control
Constant	-3.5720***	3.5290***	-0.5177*	4.2976***
	(-4.9051)	(4.3338)	(-1.6516)	(4.9209)
Number of samples	2133	1945	1739	1739
Adjusted R^2	0.2303	0.2381	0.6178	0.2314

5. Mechanism Test

Based on the aforementioned research, this article posits that the digital transformation of enterprises enhances their environmental performance through the enhancement of green innovation capabilities and the optimization of enterprise structure. To examine the mediating effect, a stepwise regression method will be employed. The empirical model is formulated as follows:

$$GP_{i,t} = \beta_0 + \beta_1 DT_{i,t} + \beta_2 Control_{i,t} + \sum Year + \sum Ind + \varepsilon_{i,t} \quad (2)$$

$$Cost_{i,t} = \beta_0 + \beta_1 DT_{i,t} + \beta_2 Control_{i,t} + \sum Year + \sum Ind + \varepsilon_{i,t} \quad (3)$$

$$EP_{i,t} = \gamma_0 + \gamma_1 DT_{i,t} + \gamma_2 GP_{i,t}(Cost_{i,t}) + \gamma_3 Control_{i,t} + \sum Year + \sum Ind + \varepsilon_{i,t} \quad (4)$$

This paper employs the number of green invention patent applications and green utility model patent applications as measures of enterprises' green technology innovation capabilities. A higher number of green patent applications indicates a stronger green technology innovation capability. Additionally, the operating cost rate of the enterprise (i.e., the ratio of operating cost to operating income) is selected as a measure of the level of structural optimization. The explained variable in Model (2) is green technology innovation capability, while the explained variable in Model (3) is the operating cost rate.

Table 4 presents the results of the stepwise regression analysis. In column (1), the regression coefficient of DT is 0.0500, and it is significantly positive at the 1% level, indicating that the digital transformation of enterprises can significantly enhance the level of green technology innovation. After including the mediating variable GP, the regression coefficient of DT in column (2) remains significantly positive, suggesting that the digital transformation of enterprises further enhances the level of environmental performance by improving the green technology innovation. In column (3), the regression coefficient of DT is -0.0065, and it is significantly negative at the 5% level, indicating that digital transformation reduces the operating cost rate of enterprises, thereby promoting structural optimization. Moreover, when including the mediating variable Cost, the regression coefficient of DT in column (4) is 0.0906, and it is significantly positive at the 5% level, indicating that the digital transformation of enterprises further improves the level of corporate environmental performance by enhancing the optimization of corporate structure.

Table 4. Mediating effect test results

	Green technology innovation level		Structural optimization	
	(1)	(2)	(3)	(4)
Variable	GP	EP	Cost	EP
DT	0.0500***	0.0893*	-0.0065**	0.0906**
	(10.7497)	(1.8868)	(-1.9855)	(2.0466)
Controls	yes	yes	yes	yes
Year	Control	Control	Control	Control
Industry	Control	Control	Control	Control
Constant	3.9765***	-0.3709	-0.0184	-0.3042
	(5.2202)	(-0.8822)	(-0.4757)	(-0.7847)
Number of samples	24604	2068	2148	2148
Adjusted R^2	0.1547	0.2300	0.5126	0.2373

6. Further Research

From the perspective of enterprises themselves, enterprises with different attributes and strengths exhibit variations in property rights, growth, and R&D investment intensity. These differences lead to varying impacts of digital transformation on the environmental performance of enterprises. Additionally, the level of attention from external analysts also varies, resulting in differences in monitoring functions, which further influence the improvement of environmental performance. To delve deeper into this heterogeneity, this paper employs sub-sample regression analysis. It conducts heterogeneity tests based on the nature of corporate property rights, corporate growth, R&D investment intensity, and analyst attention to explore the specific effects of digital transformation on corporate environmental performance.

6.1. Nature of Property Rights

State-owned enterprises and non-state-owned enterprises differ in terms of political resources, financial support, and supervision. State-owned enterprises possess advantages in government policies and human resource support compared to non-state-owned enterprises. Given the special ownership attributes of state-owned enterprises, national policies promoting digital transformation and green development are typically better implemented and enforced in these enterprises. In recent years, the government has been actively promoting digital transformation and "dual carbon" policies, effectively supporting and supervising state-owned enterprises, resulting in better performance compared to non-state-owned enterprises. However, private enterprises face higher risks and uncertainties during digital transformation and encounter greater financial pressures. Although private enterprises demonstrate a strong willingness to undergo digital transformation, financial constraints often hinder the progress, leading to limited impacts on environmental performance. Based on the nature of property rights, the sample enterprises are divided into two groups: state-owned enterprises and non-state-owned enterprises. From columns (1) and (2) in Table 5, it is evident that digital transformation has significantly promoted the environmental performance of state-owned enterprises, with a regression coefficient of 0.2668, significant at the 1% level. Conversely, non-state-owned enterprises exhibit a negative correlation, indicating that the promotion effect of digital transformation on corporate environmental performance is more prominent in state-owned enterprises.

6.2. Enterprise Growth

During the process of digital transformation, high-growth enterprises outperform low-growth enterprises in terms of speed, profitability, financial strength, and level of digitalization. They undergo a faster digital transformation and achieve more noticeable improvements in environmental performance. The sample is divided into two groups based on the median growth rate of main business income: high-growth enterprises and low-growth enterprises. From columns (3) and (4) in Table 5, it can be observed that digital transformation has a significant positive effect on the environmental performance of high-growth enterprises. The regression coefficient is 0.1752, which is significant at the 1% level. However, under the sample of low-growth enterprises, although the regression coefficient of digital transformation on environmental performance is positive, it does not pass any usual level of significance test. This indicates that the promotion effect of digital transformation on corporate environmental performance is more prominent in high-growth enterprises.

6.3. R&D Investment

Intensity The significance of digital transformation for green innovation in enterprises is evident. It provides enterprises with abundant data resources and collaborative innovation platforms. However, different levels of R&D investment intensity can lead to varied effects on green innovation, thereby influencing the environmental performance of enterprises. Enterprises with high R&D investment intensity have stronger R&D capabilities. After undergoing digital transformation, these enterprises can allocate resources more efficiently and achieve technological synergies, thus enhancing their level of green technological innovation and improving their environmental performance. The sample is divided into two groups based on the median R&D investment intensity of enterprises: high R&D investment intensity enterprises and low R&D investment intensity enterprises. From columns (5) and (6) in Table 5, it can be seen that digital transformation has a significant positive effect on the environmental performance of high R&D investment intensity enterprises. The regression coefficient is 0.1427, which is significant at the 5% level. However, under the sample of low R&D investment intensity enterprises, although the regression coefficient of digital transformation on environmental performance is positive, it does not pass any significance test at usual levels. This indicates that digital transformation has a greater impact on improving the environmental performance of enterprises with high R&D investment intensity compared to those with low R&D investment intensity.

Table 5. Heterogeneity test

	State-owned enterprises	Non-state-owned enterprises	High growth	Low growth	High R&D investment	Low R&D investment
	(1)	(2)	(3)	(4)	(5)	(6)
Variable	EP	EP	EP	EP	EP	EP
DT	0.2668***	-0.0214	0.1752***	0.0176	0.1427**	0.0047
	(4.2759)	(-0.3270)	(2.8094)	(0.2743)	(2.0160)	(0.0828)
Controls	yes	yes	yes	yes	yes	yes
Year	Control	Control	Control	Control	Control	Control
Industry	Control	Control	Control	Control	Control	Control
Constant	3.1949***	4.3392***	4.7461***	3.3810***	5.9336***	2.6472***
	(3.2967)	(2.9838)	(4.3481)	(3.1527)	(3.4216)	(2.5992)
Number of samples	1292	856	1069	1069	1048	1100
Adjusted R^2	0.2939	0.1442	0.2792	0.2088	0.2812	0.2391

7. Research Conclusions and Enlightenment

The era of the digital economy has arrived, and digital transformation has become a crucial path for manufacturing enterprises to achieve high-quality development. To gain a comprehensive understanding of this issue, this paper analyzes the impact of digital transformation on the environmental performance of Chinese companies based on the development of new-generation information technology and data from China's A-share listed companies from 2010 to 2019. The main conclusions are as follows: (1) Overall, digital transformation significantly improves the environmental performance level of enterprises. This conclusion remains valid even after changing the measurement method of explained variables, sample size, and conducting various robustness tests for endogenous variables. (2) In terms of the impact mechanism, the digital transformation of enterprises promotes the improvement of environmental performance through two mechanisms: enhancing green technology innovation capabilities and optimizing production structure. (3) The investigation into heterogeneity demonstrates that the favorable impact of digital transformation on corporate environmental performance is contingent upon various internal and external factors. Specifically, when examining the external environment, it becomes evident that enterprises with high levels of analyst attention experience a more substantial enhancement in their environmental performance as a result of digital transformation. Similarly, considering the internal environment, digital transformation exerts a more pronounced influence on improving environmental performance within state-owned enterprises, high-growth companies, and enterprises with a high intensity of R&D investment.

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