Digital Transformation and Corporate Environmental Performance: An Empirical Analysis of Industry Heterogeneity Differences

Jiangyi Xia [1, #], Ziying Wu [2, #, *], Yushu Fan [3, #]

[1] Honors College, Tianjin Foreign Studies University, Tianjin, China, 300011

[2] Business School, Hebei Normal University, Shijiazhuang, China, 050024

[3] Nanchang Institute of Technology, Nanchang Institute of Technology, Nanchang, China, 330108

* Corresponding Author Email: wzyy200301@163.com

[#]These authors contributed equally

Abstract. Against the dual backdrop of the digital economy and green development, digital transformation has emerged as a crucial pathway for enterprises to enhance their environmental performance. Based on the data of Chinese A-share listed companies from 2008 to 2021, the research empirically analyzes the effect of digital transformation on the environmental performance of enterprises and its industry differences. The research findings are as follows:(1) Digital transformation has a significantly positive impact on the environmental performance of enterprises, and this effect is achieved by promoting green technological innovation and optimizing the quality of internal control;(2)The heterogeneity analysis indicates digital transformation has a more remarkable effect on improving the environmental performance of low-pollution industries, non-high-tech enterprises, as well as non-manufacturing industries. However, due to the relatively high governance costs, the effects are relatively limited in high-pollution industries and the manufacturing industry. This research provides an important basis for the government to formulate targeted digital environmental protection policies and for enterprises to implement differentiated transformation strategies. It also has certain practical enlightenment significance for promoting the integration of digital economy as well as green development.

Keywords: Digital transformation, Environmental performance, Green innovation, Internal control, Industry differences.

1. Introduction

Driven by the dual forces of the digital economy and green development, digital transformation has become a crucial path for enterprises to enhance their competitiveness and achieve sustainable development. At the policy level, the Chinese government has put forward the "dual carbon" goal and regarded digitization as an important means to promote the transformation of the energy structure and achieve green and low-carbon development. For example, the "14th Five-Year Plan for the Development of the Digital Economy" requires that by 2025, the added value of the core industries of the digital economy should account for 10% of the GDP. The European Union, through the Green New Deal and the Carbon Border Adjustment Mechanism, requires enterprises to implement full-life-cycle carbon footprint management, forcing the environmental compliance of the supply chain[1]. Market demand and technological drive have further accelerated this process. Consumers' awareness of environmental protection has significantly increased. In response to market demand, enterprises are using technologies like the IOT, big data, as well as AI to optimize environmental management. For example, the energy industry uses smart sensors to achieve real-time energy consumption monitoring and the service industry uses AI algorithms to optimize logistics routes. These practices have significantly reduced carbon emissions and resource consumption [2]. Currently, the academic research on the connection of digital transformation with corporate environmental performance has made certain progress. Some scholars, based on the resource-based view, believe digital technologies can improve corporate environmental performance via optimizing resource allocation. Other studies, starting from institutional theory, point out that policy pressure prompts enterprises to meet compliance requirements through digital transformation[3]. However, most of the existing studies focus on a single industry or discuss the overall effect in a general way, lacking in-depth exploration of industry differences and intermediary mechanisms[4].The marginal contribution of the study is reflected in two aspects. First of all, through empirical analysis, it reveals the general and industry specific impacts of digital transformation on corporate environmental performance breaking the limitations of previous research that focused solely on individual industries or provided overly broad analyses. Second, it explores key mediating pathways such as green innovation and internal control, elucidating the internal mechanisms by which digital transformation influences corporate environmental performance. The research results not only help enterprises to formulate differentiated digital transformation strategies, but also provide policymakers with the basis for precise policies in the industry, and promote the deep integration of digital economy as well as green development.

2. Theoretical Analysis and Research Hypotheses

2.1. The Overall Relationship between Digital Transformation and the Environmental Performance of Enterprises

With the deepening of digital transformation, enterprises can leverage digital technologies to empower environmental protection, conduct precise monitoring of the product life cycle, reduce energy consumption during the production and maintenance processes, and minimize harmful pollutants[5], thereby improving their corporate environmental performance. On the one hand, according to the resource-based theory, the digital transformation of enterprises enables them to collect data in a timely manner for energy management and effective resource allocation, thus reducing energy consumption as well as carbon emissions and promoting environmental performance[6]. The information asymmetry theory posits that there are differences in the ability of enterprises to master information internally. Digital transformation can accelerate the speed of information dissemination, alleviate internal information asymmetry as well as the short-sighted behavior of management, enhance the internal information sharing and processing capabilities of enterprises, and promote corporate innovation and cooperation. This enables enterprises to promptly develop products that meet consumers' needs and the green development strategy[7].Based on the above analysis, Hypothesis 1 is proposed:

H1: Digital transformation significantly enhances corporate environmental performance.

2.2. The Mediating Role of Green Innovation

Digital transformation stimulates green technological innovation. It can improve the efficiency of enterprises' green technological innovation, the ability to transform green scientific and technological achievements, as well as the ability of enterprises to quickly integrate data such as energy resource information and pollution emissions, thus promoting continuous technological upgrading of enterprises[8].Besides, digital transformation enables enterprises to quickly obtain data as well as information related to green innovation at a relatively low cost, lowering the risks of green technology R&D, and thus promoting the green innovation performance of enterprises[9]. Based on the above analysis, Hypothesis 2 is proposed:

H2: Digital transformation enhances corporate environmental performance by promoting green technological innovation.

2.3. The Mediating Role of Internal Control

Digital transformation will optimize the internal control quality of enterprises, thereby enhancing their environmental performance. Driven by digital transformation, sound internal control can enable enterprises to effectively supervise and control all internal business processes, ensure the rational utilization and effective allocation of enterprise resources, avoid resource waste, reduce unnecessary expenses, and improve resource utilization efficiency, thus creating more value for enterprises[10].

Besides, internal control improvement can timely detect non-compliant pollution emissions of enterprises, and at the same time reduce the possibility of management falsification of environmental disclosure reports[11]. Based on the above analysis, Hypothesis 3 is proposed:

H3: Digital transformation enhances corporate environmental performance by improving the quality of internal control.

3. Model Design and Variable Explanation

3.1. Sample Selection and Data Sources

The sample selection of the research takes the A-share listed companies in China from 2008 to 2021 as the initial research objects. The selected enterprises, as the core entities of the Chinese economy, are highly representative. Sample screening follows the following criteria:(1) Exclude enterprises in the financial industry to avoid interference from industry characteristics;(2) Eliminate enterprises with poor operations such as ST as well as *ST to eliminate the effect of abnormal financial conditions;(3) Eliminate enterprises with missing major variables to ensure data integrity. The internal control data of the enterprise is sourced from the Dibo database, as well as the remaining data are all taken from the CSMAR database. To reduce the disturbance of outliers to the research results, tailing processing was carried out for each continuous variable at the 1% and 99% quantile levels.

From the perspective of data representativeness, the industry coverage of A-share listed companies enables it to effectively reflect the characteristics of different industries. By eliminating special industries and abnormal enterprises, it further focuses on normal business entities. Moreover, the time span of the research samples covers the rapid development stage of China's digital economy after 2012 and the key period after the implementation of the new Environmental Protection Law in 2015.It helps to dynamically capture the evolution of the connection of digital transformation with environmental performance. The core variable adopts a multi-dimensional and detailed measurement method, which avoids the one-sidedness of a single indicator and ensures that the data can reflect the actual situation of the enterprise's digital transformation level as well as environmental performance.

3.2. Model Design

To explore the connection of the digital transformation of enterprises with their environmental performance, the regression model (1) is established:

$$EP_{i,t} = \alpha_0 + \alpha_1 Digit_{i,t} + \alpha_2 Controls_{i,t} + Year_{i,t} + Ind_{i,t} + \varepsilon_{it} \quad (1)$$

In Model (1), EP is the explained variable, representing the environmental performance of the enterprise; Digit is the explanatory variable, representing the disclosure of corporate environmental information; Controls represent the control variables; Year and Ind are fixed effects, representing the year fixed effect and the industry fixed effect respectively; ε is the random disturbance term; the subscripts i and t represent individual enterprises and time.

In order to further explore the influence mechanism of the digital transformation of enterprises on their environmental performance, this paper constructs Model (2):

$$MV_{i,t} = \beta_{01} + \beta_{11} Digit_{i,t} + \beta_{12} Controls_{i,t} + Year_{i,t} + Ind_{i,t} + \varepsilon_{it} \quad (2)$$

$$EP_{i,t} = \beta_{02} + \beta_{12} Digit_{i,t} + \beta_{22} Controls_{i,t} + \beta_3 MV_{i,t} + Year_{i,t} + Ind_{i,t} + \varepsilon_{it} \quad (3)$$

In Model (2), MV is the mediating variable. It represents the green innovation of the enterprise (GI) and the enterprise internal control quality (EICQ).

3.3. Variable Description

This paper uses the CSMAR database, referring to the practices of scholars such as Wu Fei (2021), and constructs an index system. For details, please refer to Table 1.

Table 1. Construction of the Index System

Types of variables	Variable Symbol	Variable Name	Variable Definition Description
Explained variable	EP1	Enterprise Environmental Performance 1	It is constructed through the method of comprehensive scoring. The environmental performance consists of the following parts:(1) Whether the enterprise has an environmental protection concept;(2)Whether there are environmental protection objectives;(3)Whether an environmental protection management system has been adopted;(4)Whether environmental protection education and training have been carried out; (5) Whether there are special environmental protection behaviors;(6)Whether an emergency response mechanism for environmental incidents has been adopted;(7)Whether the enterprise has the "Three Simultaneities" system;(8) Whether it has received honors or awards in the field of environmental protection; (9)Whether the enterprise has passed the ISO14001 certification. The enterprise will get 1 point for each item it meets in the above, and 0 point if it does not meet. The total score is taken as the proxy variable for the enterprise environmental performance.
	EP2	Enterprise Environmental Performance 2	Use the comprehensive score of environmental protection and governance to measure EP2, which specifically includes six aspects: waste gas reduction, wastewater reduction, dust reduction, utilization and disposal of solid waste, noise and light control, and implementation of clean production. According to their disclosure levels (whether disclosed, qualitative or quantitative), 0, 1 or 2 points are respectively assigned.
Explanatory variable	Digit1	Digital Transformation 1	Count the word frequencies of 76 digital-related words in five dimensions: artificial intelligence technology, big data technology, cloud computing technology, blockchain technology, as well as digital technology application
	Digit2	Digital Transformation 2	Count the word frequencies of 99 digital-related words in four dimensions: digital technology application, Internet business model, intelligent manufacturing, and modern information system
Mediating variable	GI	Green Innovation	The total number of green invention patents and green utility model patents applied for by companies
	EICQ	Internal Control	Dibei Internal Control Index
Control variable	Lev	Asset-liability Ratio	The Proportion of the Total Liabilities of the Enterprise in the Total Assets in the Current Year
	Rank1	Shareholding Ratio of the Largest Shareholder	(The Number of Shares Held by the Largest Shareholder / The Total Number of Shares of the Company) × 100%
	Rcr	Ratio of Operating Cost to Operating Revenue	Operating Cost / Operating Revenue
	Car	Cash Asset Ratio	(Total Cash Assets / Total Current Liabilities) × 100%
	TQ	Tobin's Q Value	(The Price per Share × the Number of Outstanding Shares + the Net Assets per Share × the Number of Non-tradable Shares + Total Liabilities) / Total Assets
	Ohr	Management Expense Ratio	Management Expenses/ Main Business Revenue × 100%
	Board	Board of Directors Size	The Number of In-service Directors at the End of the Year

4. Empirical Analysis

4.1. Descriptive Analysis

The table presents the descriptive statistical results of the variables. The mean value of the explained variable, corporate environmental performance is 0.736, indicating that the overall comprehensive scores of enterprises in various indicators for measuring environmental performance are relatively low, and there is still room for improvement in the overall performance of enterprises in environmental protection. In addition, we find the minimum value of the corporate environmental performance variable is 0, and the maximum value is 2.197, showing a large difference. This result, on the one hand, indicates that there are significant differences in environmental performance among enterprises, and on the other hand, such differences also provide a source of variability for this study. The mean value of the explanatory variable, digital transformation (Dig) is 2.789, suggesting that enterprises have made a certain degree of investment in dimensions related to digital transformation. However, there are also significant differences between the maximum and minimum values, reflecting that the degrees of digital transformation vary greatly among different enterprises. In addition, for control variables such as the mean value of the debt-to-asset ratio (Lev) being 0.429, and the mean value of the shareholding ratio of the largest shareholder (Rank1) being 34.804 etc., the mean values, standard deviations, as well as maximum and minimum values of different variables show that these control variables have obvious differences among different enterprises, which can play a good role in controlling this study.

Table 2. Descriptive Statistics

Variable	Obs	Mean	Std. dev.	Min	Max
EP1	30,079	0.736	0.690	0	2.197
Digit1	30,079	2.789	1.251	0	5.811
Lev	30,079	0.429	0.203	0.0561	0.887
Rank1	30,079	34.804	14.933	8.660	74.450
Rcr	30,079	0.715	0.175	0.170	1.005
Car	30,079	0.159	0.119	0.011	0.588
TQ	30,079	0.585	0.486	-0.150	2.143
Ohr	30,079	0.086	0.067	0.008	0.391
Board	30,079	8.643	1.710	5	15

4.2. Benchmark Regression

To analyze the relationship between corporate environmental performance and digital transformation, the research conducts a regression analysis according to Model (1), and the corresponding regression results are displayed in Table 3. Column (1) represents the regression results without controlling for fixed effects as well as without adding control variables. Column (2) and Column (3) represent the regression results after controlling for fixed effects and adding control variables. Column (4) represents the regression results after simultaneously controlling for fixed effects and adding control variables. The research finds that regardless of whether fixed effects as well as control variables are considered, the coefficient of the digital transformation variable is remarkably positive at the 1% level. This suggests that digital transformation has a remarkable positive impact on corporate environmental performance. That is, the higher the level of digital transformation of an enterprise, the higher its environmental performance level, which supports Hypothesis 1.

Table 3. Benchmark Regression

	(1)	(2)	(3)	(4)
	EP1	EP1	EP1	EP1
Digit1	0.033*** (10.49)	0.054*** (17.46)	0.040*** (9.26)	0.039*** (9.01)
Lev		-0.008 (-0.37)		0.061** (2.24)
Rank1		0.003*** (11.19)		-0.000 (-0.39)
Rcr		-0.172*** (-6.69)		-0.042 (-1.19)
Car		-0.635*** (-18.05)		0.051 (1.51)
TQ		-0.099*** (-11.25)		-0.025*** (-2.66)
Ohr		-1.918*** (-29.32)		-0.332*** (-4.75)
Board		0.037*** (16.33)		-0.000 (-0.15)
_cons	0.643*** (66.26)	0.609*** (17.38)	1.031*** (7.63)	1.021*** (7.14)
Individual	Non-Fixed	Non-Fixed	Fixed	Fixed
Year	Non-Fixed	Non-Fixed	Fixed	Fixed
N	30079	30079	30079	30079
F	110.107	342.809	14.499	14.498
r2	0.004	0.084	0.670	0.670

Note: The values in parentheses are t-values. “***、**、*”represent significance at the 1%, 5%, and 10% levels (the same below).

4.3. Endogeneity test

4.3.1. One-period lag method

The explanatory variables are regressed one period behind in the model to avoid the endogeneity problem caused by reverse causality. The estimation results are shown in Table 4, which is still remarkably positive at the 1% level, consistent with the benchmark regression results.

Table 4. Regression of Lagged Independent Variables

	(1)	(2)
	EP1	EP1
Digit1	0.039*** (9.01)	
L.Digit1		0.028*** (5.94)
Individual	Fixed	Fixed
Year	Fixed	Fixed
N	30079	25650
F	14.498	14.527
r2	0.670	0.683

4.3.2. Instrumental variable method

To prevent the problem of missing variables during the research process, this study also adopted the two-stage least squares method based on the instrumental variable method for endogeneity testing. Drawing on the practice of Xu et al. (2023), we select the number of Internet users in the city where the enterprise office is located as the instrumental variable for digitalization. There are two reasons.

Firstly, the number of Internet users in a region reflects the development level of the network infrastructure in that area, which will affect the application and acceptance of information technology by local enterprises, and further influence the degree of digital transformation of enterprises. On the other hand, the number of Internet users in a region itself does not directly affect the environmental performance of enterprises as well as meets exogenous requirements. To examine the validity of instrumental variables, the study tested multiple statistics: Firstly, the Anderson canon.corr. LM statistic of the first-stage regression is 32.133, which is significant at the 1% level. It rejects the null hypothesis, indicating that it has passed the unidentifiability test and proves that there is a correlation between the instrumental variable as well as the explanatory variable. Second, there is no issue with weak instrumental variables, as indicated by the Cragg-Donald Wald F statistic of 28.583, which is higher than the threshold value of 16.38 at the 10% level. In the meanwhile, an over-identification test is not necessary since the number of endogenous variables in the test is equal to the number of instrumental variables. Finally, the Endogeneity test at 10% significance once again proves that there is an endogeneity problem in the original regression. Therefore, in conclusion, it is necessary and effective to conduct verification via the instrumental variable method in this paper.

The results of the instrumental variable estimation are displayed in columns (1) and (2) of Table 5. Column (1) indicates that IV has a significant positive relationship with Digital1.The regression coefficient of the instrumental variable of Digital1 in column (2) is significantly 0.258,which is consistent with the benchmark regression. The above results indicate that after using instrumental variables to solve possible endogeneity problems, the benchmark regression results in this study remain robust.

Table 5. Instrumental variable method test

	(1)	(2)
	First stage Digit1	Second stage EP1
IV	0.001*** (5.35)	
Digit1		0.258* (1.860)
Individual	Fixed	Fixed
Year	Fixed	Fixed
Anderson canon. corr. LM statistic	32.133***	
Cragg-Donald Wald F statistic	28.583(16.38)	
Endogeneity test	3.071*	
Observations	29,691	29,691
r2		-0.090

4.4. Stability Test

4.4.1. Replacement of Core Explanatory Variables

Referring to the studies of scholars such as Zhao Chenyu (2021) and Qu Yuxiao (2023), the regression was re-conducted after replacing the explained variable as well as the explanatory one respectively. The correlation coefficient between the explanatory variable and the explained variable is still remarkably positive at the 1% level, which is shown in Table 6. Hypothesis 1 is verified.

4.4.2. Adjustment of the Research Time Period (2010–2020)

(1) Avoid the interference of extreme events

Exclude the direct impact of the 2008 global financial crisis (enterprises may prioritize business recovery rather than digital transformation in the early post - crisis period); avoid the abnormal impact of the COVID-19 pandemic after 2020 (the pandemic may have accelerated digitalization but distorted environmental performance, such as fluctuations in emissions caused by supply-chain disruptions).

(2) Relatively stable economic environment

Cover the recovery period after the financial crisis (2010–2015) and the technology maturity period (2016–2020), which allows us to observe the effects of digital transformation in different economic stages.

(3) Policy consistency

Both China's 12th Five-Year Plan (2011–2015) as well as 13th Five-Year Plan (2016–2020) emphasized green development as well as digitalization, which enables us to test the superposition effect of policies.

From the results after adjusting the research time, it can be seen that the correlation coefficient between the explanatory variable and the explained variable is significantly positive at the 1% level, and Hypothesis 1 is verified again.

Table 6. Adjustment of the Research Time Period

	(1)	(2)	(3)	(4)
	EP1	EP1	EP2	EP2
Digit1	0.035*** (7.17)		0.017*** (2.88)	
Digit2		0.033*** (6.90)		0.016*** (2.82)
Individual	Fixed	Fixed	Fixed	Fixed
Year	Fixed	Fixed	Fixed	Fixed
N	24292	24292	24292	24292
F	14.262	14.258	13.063	13.062
r2	0.692	0.692	0.673	0.673

4.5. Mediating Effect

4.5.1. Green Innovation (GI)

Green patents are more stable, dependable, and timely than approved patents, and they may demonstrate the production potential of green innovation. Accordingly, the total number of green utility model and green invention patent applications filed by publicly traded corporations is used in this study to assess green innovation.

The benchmark regression is displayed in column (1) of Table 7, the regression of corporate digital transformation on green innovation is displayed in column (2), and the regression results of corporate digital transformation on corporate environmental performance after the factor of green innovation is added are displayed in column (3). At the 5% level, all of the coefficients are substantially positive. Thus, it has been confirmed that green innovation may enhance business environmental performance through digital transformation. Digital transformation provides enterprises with advanced technologies and massive data. Through big data analysis, it accurately perceives the green demands and policy orientations of the market, guiding enterprises to increase investment in green R&D, develop environmentally friendly products as well as technologies, stimulating green innovation, and thereby mediating the improvement effect of digital transformation on the environmental performance of enterprises. Hypothesis 2 is verified.

4.5.2. Enterprise Internal Control Quality (EICQ)

The internal control index of listed companies shows the effectiveness of a company's internal control system. It is usually used to reflect a company's control capabilities and levels in aspects such as internal management, financial reporting, compliance, and risk management. The Dibor Internal Control Index and its rating data are important financial data analysis tools. Based on this, this paper uses this index to evaluate the performance of A-share listed companies in terms of internal control.

Column (4) in Table 7 shows the regression of corporate digital transformation on internal control, and column (5) shows the regression results of corporate digital transformation on corporate environmental performance after adding the factor of internal control. The coefficients are all remarkably positive at the 1% level. So it is verified corporate digital transformation can elevate corporate environmental performance through the level of internal control. Digital transformation breaks down departmental barriers through information systems, achieves data sharing, enhances the transparency, standardization and efficiency of enterprise operations, and strengthens the effectiveness of internal control. Effective internal control prompts enterprises to implement environmental protection requirements, rationally allocate resources, and ultimately enhance environmental performance. That is, digital transformation positively affects environmental performance by optimizing internal control. Hypothesis 3 is verified.

Table 7. Research on the Mediating Effect of Green Innovation and Internal Control

	(1)	(2)	(3)	(4)	(5)
	EP1	GI	EP1	EICQ	EP1
GI			0.014** (2.47)		
EICQ					0.009*** (2.91)
Digit1	0.039*** (9.01)	0.026*** (5.34)	0.039*** (8.92)	0.044*** (4.87)	0.039*** (8.92)
Individual	Fixed	Fixed	Fixed	Fixed	Fixed
Year	Fixed	Fixed	Fixed	Fixed	Fixed
N	30079	30079	30079	30079	30079
F	14.498	17.787	14.499	2.211	14.501
r2	0.670	0.714	0.670	0.237	0.670

4.6. Heterogeneity Analysis

4.6.1. High-pollution industries and low-pollution industries

The production processes of highly polluting industries are complex and the environmental load is heavy. The digital transformation requires high investment for the intelligent transformation of equipment and the upgrade of energy management systems. Moreover, the cost of pollution control squeezes the transformation funds, which limits the improvement of their environmental performance. Low-pollution industries face less pressure in environmental governance. They can focus resources on digital transformation and precise customer demands, and it is easier to optimize resource allocation and improve environmental performance through digitalization. The data are shown in Table 8 (1) and (2).

4.6.2. High-tech enterprises and non-high-tech enterprises

Although high-tech enterprises have technological advantages, the large amount of resources invested in technological research and development may distracts digital transformation, as well as the role of digitalization in improving environmental performance in some fields is limited. Non-high-tech enterprises, free from constraints of complex technical systems, can directly apply digitalization to key business operations, and thus have stronger adaptability and more significant achievements in improving environmental performance. The data are shown in Table 8 (3) and (4).

4.6.3. Manufacturing industries and non-manufacturing industries

The manufacturing industry is constrained by the traditional production mode. The high costs of equipment renewal and process reengineering restrict the improvement effect of digitalization on environmental performance. The non-manufacturing operation model is flexible, the cost of digital transformation is low, and it can efficiently utilize digital means to optimize business processes, performing better in terms of environmental performance improvement. The data are shown in Tables 8 (5) and 6.

Table 8. Heterogeneity Regression

	(1)	(2)	(3)	(4)	(5)	(6)
	H_pol=1	H_pol=0	H_tech=1	H_tech=0	Manu=1	Manu=0
Digit1	0.036*** (4.43)	0.048*** (8.96)	0.035*** (5.50)	0.048*** (7.72)	0.035*** (6.22)	0.039*** (5.49)
Individual	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
Year	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
N	9022	20620	15805	13815	19450	10180
F	7***	14***	9***	8***	9***	6***
r2	0.663	0.657	0.670	0.679	0.664	0.690
ChowTest	10.93		15.39		29.61	

5. Conclusions and Implications

5.1. Research Conclusions

As a key link in promoting enterprises to conduct environmental governance, digital transformation helps enterprises evaluate their own environmental performance and continuously improve their environmental performance,playing a crucial role in the development of China's green economy.Based on the financial statement data of listed enterprises from 2008 to 2021,this paper examines whether the digital transformation of enterprises will have a significant impact on their environmental performance.The study finds that the digital transformation of enterprises has remarkably improved their environmental performance.It is further found that the manufacturing industry’s digital transition mainly leads to an improvement in the level of corporate environmental performance by optimizing production processes,enhancing the energy efficiency of equipment,and developing green manufacturing technologies.At the same time,it promotes the innovation of green products.Through digital means,more environmentally friendly products are designed and developed to reduce the environmental impact throughout the product life cycle, such as the energy-saving design of smart home appliances.The heterogeneity analysis reveals that digital transformation is more effective in boosting corporate environmental performance for secondary and tertiary industries, and also for large - scale enterprises.

5.2. Policy Implications

First,government level:The government should incorporate integrate the digital transformation of enterprises as a pivotal element into the core strategy for green economic development,and promote the improvement of environmental performance through policy guidance and resource allocation.For one thing,improve the fiscal and tax incentive mechanism,and provide tax relief and R & D subsidies to enterprises that actively carry out digital transformation and effectively improve environmental performance.For another,accelerate the construction of cross-departmental data sharing platforms,integrate data resources such as environmental monitoring and industrial policies,and provide accurate digital transformation guidance for enterprises.For enterprises in the secondary and tertiary industries and large-scale enterprises,formulate differential support policies to encourage them to play a demonstration role and drive the coordinated transformation for the upstream and downstream sectors of the industrial chain.

Second, enterprise level: Enterprises should actively seize the opportunities of digital transformation and integrate the concept of green development into their strategic layout. Manufacturing enterprises can optimize production processes based on large dataset analysis,use Technology of the Internet of Things for monitor equipment energy efficiency in real-time,and increase investment in the R&D of green manufacturing technologies.Meanwhile,they can innovate product design with digital means and develop low-carbon and environmentally friendly products.Small and medium-sized enterprises can reduce transformation costs by joining industry digital transformation alliances to share technologies and experiences.In addition,enterprises need to establish and improve an environmental performance evaluation system and use digital technology to achieve dynamic optimization of environmental management.

Third, social public level: The social public should actively play the role of supervision and promotion to form a good atmosphere of public participation in green development.Popularize the knowledge of digital transformation and environmental protection through media publicity, community education,etc.,and enhance the public's awareness and recognition of green products.Encourage consumers to give priority to environmentally friendly digital products,and use market demand to force enterprises to strengthen green innovation.In the meantime,unblock public supervision channels,report enterprises' environmental violations in a timely manner, urge companies to earnestly fulfill their ecological duties,and jointly advance the high-standard development of China's green economy.

References

[1] Feng Hao, Zhong Qingqi, Wang Aina. An Empirical Study on the Impact of Digital Transformation on Corporate Environmental Performance: Also on the Moderating Role of Environmental Information Disclosure [J]. Journal of Chengdu Technological University, 2025, 28 (01): 71-80.

[2] Guo Qiutong. Research on the Influence Mechanism between Digital Transformation and Corporate Environmental Performance [J]. Journal of Dezhou University, 2024, 40 (06): 59-63.

[3] Zhang Chuanbing, Zhao Yiting, Xiao Tingting. Research on the Impact of Digital Transformation on Corporate Environmental Performance [J]. Statistics & Information Forum, 2025, 40 (01): 92-105.

[4] Yu Changhong. The Impact of Green Technology Innovation of Agricultural Listed Companies on Environmental Performance: Based on the Dual Mediating Mechanism of Corporate Social Responsibility and Digital Transformation [J]. Science Technology and Industry, 2024, 24 (17): 127-135.

[5] Wang Xiaohong, Li Na, Chen Yu. Redundant Resources Moderation, Digital Transformation and High-Quality Development of Enterprises [J]. Journal of Shanxi University of Finance and Economics, 2022 (08): 72-84.

[6] Wang Bo, Kang Qi. Digital Transformation and Corporate Sustainable Development Performance [J]. Economic Management Journal, 2023,45 (06): 161-176.

[7] Ren Yangjun, Tian Ze, Liu Chao, et al. Digital Transformation and Green Innovation of Energy Enterprises: A Heterogeneity Study of Production Processes and Business Models [J]. Enterprise Economy, 2023, 42 (12): 96-106.

[8] Yang Lihong, Jia Ruyun. Can Digital Transformation Promote the Improvement of Corporate Green Innovation Performance? ——Based on the Data of A-share Listed Companies in China [J]. Ecological Economy, 2024, 40 (03): 64-74.

[9] Sun Mengyue, Hou Yan. How Does Digital Transformation Affect the High-Quality Development of Enterprises? ——Based on the Moderating Role of the Level of Digital Inclusive Finance [J]. Contemporary Economy, 2023, 40 (11): 35-43.

[10] CHIARINI A.Industry 4.0 technologies in the manufacturing sector: Are we sure they are all relevant for environmental performance? [J]. Business Strategy and the Environment, 2021, 30 (07):3194-3207.

[11] Guo Qiutong. The Impact Mechanism of Digital Transformation on Corporate Environmental Performance [J]. Journal of Dezhou University, 2024,40 (06):59-63.