Digital Transformation, Absorptive Capacity and Enterprise Esg Performance: A Case Study of Strategic Emerging Industries

Wenjun Li and Mu Zhang *

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Article

Digital Transformation, Absorptive Capacity and Enterprise ESG Performance: A Case Study of Strategic Emerging Industries

Wenjun Li [1,2] and Mu Zhang [2,*]

[1] School of Big Data Application and Economics, Guizhou University of Finance and Economics; Guiyang 550025, China
[2] Guizhou Institution for Technology Innovation & Entrepreneurship Investment, Guizhou University of Finance and Economics; Guiyang 550025, China
* Correspondence: zhangmu01@163.com; Tel: +86-15285565731

Abstract: Digital transformation provides new drivers for economic performance growth in enterprises, but can it further improve ESG performance and support sustainable development? Based on the perspective of resources and capabilities, this paper uses the relevant data of 1588 listed companies in strategic emerging industries from 2011 to 2021 to study the differential impact of digital transformation on enterprise ESG performance, and further tests the mediating role of absorptive capacity and the moderating role of regional digital level. The research results indicate that: firstly, digital transformation of enterprises can positively promote the improvement of ESG performance; Secondly, there are significant differences in the impact of digital transformation on the ESG performance of enterprises in terms of property rights and industry characteristics. The ESG performance of state-owned enterprises and high-end equipment manufacturing enterprises is more sensitive to digital transformation; Thirdly, absorptive capacity plays a mediating role between digital transformation and corporate ESG performance; Fourthly, the positive regulation of regional digital level promotes the ESG performance of enterprises through digital transformation. The research conclusion is based on a digital perspective, providing relevant insights for improving the ESG performance of strategic emerging industry enterprises and expanding their ESG development paths.

Keywords: digital transformation; absorption capacity; enterprise ESG performance; strategic emerging industries; regional digitalization level

1. Introduction

Strategic emerging industries are industries that have a significant leading and driving role in the overall and long-term development of the economy and society based on major breakthroughs in cutting-edge technologies and major development needs. As a deep integration of emerging technologies and industries, strategic emerging industries represent the direction of the next round of technological revolution and high-end industrial transformation, and are key areas for cultivating and developing new technologies, products, and driving forces, as well as gaining future global competitive advantages [1]. In the current wave of industrial digitalization, can strategic emerging industry enterprises (hereinafter referred to as SEIEs) make full use of their own advantages to enhance their performance in society, environment, governance, and other aspects through digital transformation, gain long-term competitive advantages, and ultimately achieve sustainable development?

The essence of digital transformation of enterprises is to improve the allocation of enterprise resources and reduce the impact of external uncertainties on the enterprise through the efficient flow of data [2–5]. This will inevitably affect the operation of the enterprise [6,7]. Research shows that digital transformation can optimize resource allocation and promote the improvement of enterprise economic efficiency [8–10]; at the same time, digital transformation can empower high-quality

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development of enterprises and enhance their market competitiveness [11,12]. Most existing research focuses on the economic effects of digital transformation, and there are few studies exploring the non-economic effects of digital transformation, such as the improvement of corporate ESG performance. Corporate ESG performance, which refers to the performance of enterprises in environmental, social, governance, and other aspects, is a new evaluation system used to measure the sustainable development of enterprises [13]. As the attention of society on corporate ESG performance gradually increases, some scholars have begun to explore the relationship between digital transformation and corporate ESG performance. Research has found that digital transformation can positively promote the improvement of corporate ESG performance [14–16], and its mechanism includes promoting green technology innovation in enterprises [17], increasing external legitimacy pressure [18], and alleviating information asymmetry [19]. Most existing literature explores the impact of digital transformation on corporate ESG performance from the perspective of information asymmetry and innovation capability in dynamic capabilities of enterprises. Few studies have included absorptive capacity in dynamic capabilities of enterprises in their research, and there is a relative lack of research on the situational mechanisms of digital transformation affecting corporate ESG performance.

The dynamic capability theory emphasizes that enterprises should respond to changes in the external market environment through continuous learning, adaptation, and innovation [20]. The digital transformation of enterprises is complex and uncertain, and dynamic capabilities are the fundamental ability to ensure enterprises adapt to complex and changing external environments. WANG and AHMED (2007) believe that dynamic capabilities include absorptive capacity, adaptive capacity, and innovative capacity [21]. Previous studies have revealed the mediating role of innovative capacity in the relationship between digital transformation and corporate ESG performance [17], but there is still a lack of exploration of other sub-dimensions of dynamic capabilities. Among them, absorptive capacity enables enterprises to quickly identify and seize opportunities, scan, create, learn, share, and interpret resources in the external environment, and attempt to decentralize organizational boundaries to absorb and integrate external knowledge and resources, ultimately applying them to business practices [22,23]. Research has found that digital transformation can promote the real-time and continuous exchange of data and information between enterprises and customers, suppliers, as well as within the enterprise, expanding the knowledge coverage of enterprises and improving the efficiency of knowledge creation, sharing, and utilization [24], which is beneficial for enterprises to identify business opportunities and perceive market demand changes from a wide range of sources, promoting the improvement of absorptive capacity [25], thereby helping enterprises better cope with challenges brought by social changes, enhance their performance in social responsibility, and gain long-term competitive advantages [26]. Therefore, exploring the mediating role of absorptive capacity in the relationship between digital transformation and corporate ESG performance is of great value for deepening the portrayal of the process of digital transformation in enterprises.

Secondly, based on the resource dependence theory, the resources that organizations rely on are distributed in their environment, and organizations and environments are interdependent [27]. The production capacity of digital technology in enterprises depends to a considerable extent on the local digital infrastructure and the level of intelligence [28]. The improvement of regional digitalization can provide enterprises with more comprehensive infrastructure and communication platforms, which is conducive to the smooth promotion of digital transformation [29]. Therefore, the regional digitalization level provides strong support for the digital transformation of enterprises, and is a key scenario mechanism for the impact of digital transformation on the ESG performance of enterprises. In view of this, this article discusses the scenario mechanism of digital transformation affecting the ESG performance of enterprises from the perspective of regional digitalization level, which has practical significance for promoting the digital transformation of enterprises and improving their ESG performance.

In summary, the questions to be explored in this article are: ① Can digital transformation promote the improvement of corporate ESG performance and whether there is a differential impact? ② What is the mechanism of digital transformation affecting corporate ESG performance? ③ What

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is the situational mechanism of digital transformation affecting corporate ESG performance? To address the above issues, this article uses a sample of 1588 listed companies in strategic emerging industries in A-share to conduct empirical research on the above issues using text analysis and panel two-way fixed effect models. The possible contributions of this article are as follows: 1. Incorporating digital transformation and corporate ESG performance into the same framework enriches the research on the relationship between corporate digital transformation and corporate operations. 2. Introducing absorptive capacity broadens the research on the channels through which digital transformation affects corporate ESG performance. 3. Introducing regional digitalization levels deepens the situational mechanism of digital transformation affecting corporate ESG performance. The structure of the rest of the article is as follows: The second part proposes research hypotheses and conducts theoretical analysis; the third part introduces the research design of this article; the fourth part is the empirical research part of this article; and the fifth part is the conclusions and recommendations of this article.

2. Theoretical Analysis and Research Hypotheses

2.1. The Impact of Digital Transformation on ESG Performance of SEIEs

Firstly, the digitalization of the real economy and the embodiment of digital technology in the real world have had a significant impact on current production and lifestyles. At the same time, green and sustainable development, balanced development has become the theme of the new era, and the value of enterprise digital transformation is not only reflected in the improvement of economic performance, but also in the non-economic performance of the enterprise, such as environmental, social, governance and cultural performance [30]. Especially in the context of the digital economy, stakeholders have higher expectations for the ability and performance of enterprises in fulfilling their social responsibilities, which forces enterprises to innovate, and digital technology innovation can also improve the ability and performance of enterprises in fulfilling their social responsibilities [31]. After the digital transformation, the support of digital technology can help enterprises more efficiently enhance and improve their green image, customer reputation and product quality, thereby bringing growth in orders and profits for the enterprise [32]. At the same time, digital transformation can also bring changes in organizational structure and internal management [33], reduce the expected cost of enterprises in conducting green transformation and activities, and even change their profit model, reducing enterprise costs while creating more employment opportunities for society, thus driving sustainable economic growth [34]. In summary, this paper presents the first research hypothesis H1:

H1: Digital transformation can positively enhance corporate ESG performance.

2.2. The Impact Channels of Digital Transformation on ESG Performance of SEIEs

In the current environment of rapid development of the digital economy, in order to accelerate their own digitalization process, SEIEs need to promote the deep integration of new generation digital information technology and their own operations. Therefore, how to use digital technology to improve internal operational quality and innovation capabilities has become the key for enterprises to carry out digital transformation. The application of digital technology can help enterprises efficiently reduce the threshold for obtaining innovative resources [35], acquire more knowledge and resources for enterprises, thereby enhancing their ability to identify and absorb knowledge and opportunities, that is, absorption ability, and ultimately help enterprises create their own value and achieve high-quality development [36]. Meanwhile, industry practice and empirical research have shown that R&D innovation is a necessary technological prerequisite for enterprises to undergo production transformation [37]. The improvement of absorption capacity can significantly reduce the cost of digital transformation for enterprises and have a stable positive impact on their ESG responsibility performance [38]. Therefore, this article proposes the second research hypothesis H2:

H2: Digital transformation promotes the improvement of ESG performance by enhancing the absorption capacity of enterprises.

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2.3. The Impact Mechanism of Digital Transformation on ESG Performance of SEIEs

2.3.1. The Regulatory Role of Regional Digitalization Level

Enterprises are embedded in the regional environment, and regional digital construction is a reflection of a new external environment, which means that the effectiveness of enterprise digital transformation will be constrained by the level of regional digitization [39]. On the one hand, when the level of digitalization in a region is relatively high, the digital infrastructure in the region is more robust, laying the foundation for enterprises to carry out digital transformation, accelerating the dissemination and sharing of information and knowledge among enterprises, achieving interconnectivity between enterprises, reducing the cost of enterprise information acquisition, and promoting enterprise digital transformation [40]. On the other hand, with the acceleration of regional digital construction and the relative development of regional digital technology, coupled with strong government support for digital transformation, enterprises are better able to efficiently utilize and transform newly absorbed knowledge into new knowledge and capabilities, and thus better carry out ESG practices [41]. Therefore, this article proposes the subdivision hypothesis H3a in the third research hypothesis:

H3a: The level of regional digitalization plays a positive moderating role between digital transformation and corporate ESG performance.

2.3.2. The Heterogeneous Impact of Digital Transformation on ESG Performance of SEIEs

Digital transformation can affect the ESG performance of enterprises through green technology innovation and improving the transparency of enterprise information, etc. Existing literature has shown that the impact of digital transformation on ESG performance is heterogeneous to a certain extent, that is, the impact of digital transformation on ESG performance will be different in different industries [42], regions [43] and organization size [44]. This paper further analyzes whether there is a heterogeneous effect of digital transformation on ESG performance of enterprises under different property rights and industry properties, that is, the heterogeneity of the driving effect of digital transformation on ESG performance of enterprises such as state-owned enterprises, private enterprises and high-end equipment manufacturing enterprises.

1. Ownership Characteristics

State-owned enterprises occupy an important position in the economic development of our country and play an important role in supporting the national sustainable development strategic objectives. Therefore, SOEs have the external motivation to further improve their ESG performance to meet the requirements of ESG-related policies issued by the government and regulators [45]. In addition, compared with private enterprises, state-owned enterprises have more sufficient financial resources and more stable human and material resources to promote enterprise digital transformation and ensure enterprise ESG practice [46,47]. Through digital transformation, SOEs can improve operational efficiency, reduce resource consumption, better manage supply chains, enhance monitoring and control of environmental impact, and achieve a higher level of corporate social responsibility. Therefore, this paper proposes the subdivision hypothesis H3b of the third research hypothesis:

H3b: There are property rights differences in the driving effect of digital transformation on enterprise ESG performance.

2. Industry Nature

High-end equipment manufacturing industry, also known as advanced manufacturing industry, refers to the production and manufacturing of advanced industrial facilities and equipment with high technology and high added value [48]. The products of this industry have high added value, high technology intensity, good growth, and strong competitive advantages and development potential. Under the guidance of relevant policies, high-end equipment manufacturing industry has become a key field to achieve the goal of “double carbon”. Compared with other industries, high-end equipment manufacturing is more willing to respond to the call of the state and actively fulfill its

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corporate social responsibility [49]. Secondly, due to the particularity of its products and technologies, high-end equipment manufacturing enterprises usually have high technology research and development capabilities and innovation awareness, and can play an active role in energy conservation and emission reduction, green manufacturing and so on. These enterprises are more likely to realize the importance of environmental protection and social responsibility to the long-term development of enterprises, so they are more willing to invest resources and energy to take various measures to improve the environmental impact and improve the level of fulfilling social responsibility [50]. Therefore, this paper proposes the subdivision hypothesis H3c in the third research hypothesis:

H3c: Digital transformation has an industry-specific impact on ESG performance.

3. Research Design

3.1. Model Setting

In order to study the impact of digital transformation on ESG performance and the impact mechanism, this paper sets a benchmark regression model as shown in Equation (1):

$$ESG_{it} = \beta_0 + \beta_1 DT_{it} + \sum_j \beta_j Controls + \lambda_i + \mu_t + \varepsilon_{it} \quad (1)$$

Where ESG is the explained variable - enterprise ESG performance, DT is the explanatory variable - enterprise digital transformation, Controls is the control variable, λ_i is the individual fixed effect, μ_t is the time fixed effect, and ε_{it} is the random error term.

Most of the existing literature uses the step-by-step method proposed by Baron and Kenny (1986) to test the mediating effect [51]. However, Jiang (2022) pointed out that the main problem of the current mediating effect analysis is the abuse of the stepwise test of mediating effect grafted from psychology, which leads to errors in the mediating effect test [52]. At the same time, we observe that most of the literature uses the same control variables as the benchmark regression in the mediating effect test process, resulting in logical defects in the mediating effect test. In view of this, we refer to the operation suggestion of mediating effect analysis proposed by Jiang (2022) [52], set different control variables for different mediating variables, and construct the mediating effect test model as shown in Equation (2):

$$AC_{it} = \beta_0 + \beta_1 DT_{it} + \sum_j \beta_j Controls + \lambda_i + \mu_t + \varepsilon_{it} \quad (2)$$

Similarly, the moderating mechanism test method proposed by Jiang Ting (2022) [52] is adopted to test the moderating effect of regional digitalization level between digital transformation and enterprise ESG performance. The regression model is shown in Equation (3):

$$ESG_{it} = \beta_0 + \beta_1 DT_{it} + \beta_2 RDL_{it} + \beta_3 DT_{it} \times RDL_{it} + \sum_j \beta_j Controls + \lambda_i + \mu_t + \varepsilon_{it} \quad (3)$$

Among them, the mediating variable is the absorptive capacity of enterprises (AC), and the moderating variable is the regional digitalization level (RDL).

3.2. Variable Setting

3.2.1. Explained Variable: ESG Performance (ESG)

In this paper, the ESG rating data of the sample enterprises from 2011 to 2021 is used as the sample data. The ESG rating of the sample enterprises is divided into nine grades C-AAA, each grade corresponds to 1-9 points, and is rated once every quarter. The average value of the four quarters is used as the explained variable, and the higher the score, the better the ESG performance of the corresponding enterprises.

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3.2.2. Explanatory Variable: Digital Transformation (DT)

Based on the practice of Wu Fei et al. (2021), this paper conducts text analysis on the annual reports of sample enterprises, further obtains the word frequency numbers of six word categories, including digital transformation, artificial intelligence technology, big data technology, cloud computing technology, blockchain technology and digital application technology, in the annual reports of enterprises, and calculates their proportion in the total number of words in the annual reports [53]. This paper refers to the practice of Lu Ming and Chen Zhao (2004), and takes the natural logarithm as the explanatory variable after adding 0.00000001 to the word frequency ratio, in which the word frequency ratio of digital transformation is the core explanatory variable [54].

3.2.3. Mechanism Variable: Absorptive Capacity (AC)

Inspired by scholar Xiao Jing et al. (2023), this paper introduces absorptive capacity as a mechanism variable between digital transformation and ESG performance of enterprises [26].

3.2.4. Moderating Variable: Regional Digitization Level (RDL)

Based on the practice of Xiao Jing et al. (2023), this paper introduces regional digitalization level as the moderating variable between digital transformation and enterprise ESG performance [26]. Among them, the regional digitization level is measured by the comprehensive index of regional digitization level, which is calculated by weighting five indicators including digital output, fixed telephone penetration rate, mobile telephone penetration rate, Internet broadband penetration rate and number of web pages per capita.

3.2.5. Control Variable

To ensure the stability of the research results, we selected enterprise Size (Size), Age (Age), operating income Growth rate (Growth), asset-liability ratio (Lev), Cash flow ratio (Cash) Flow), profitability (ROA), ownership concentration index (1%) (TOP1), Board Size (Board), independent director ratio (Indep), Dual (Dual), executive shareholding ratio (M Share), and executive team size (TMT Size) as control variables. The main variable definitions in this paper are shown in Table 1:

Table 1. Variable definition.

Variable type	Name	Symbol	Definition
Explained Variable	ESG Performance	ESG	Sino-Securities ESG rating data
Explanatory Variable	Digital Transformation	DT	The proportion of digital transformation word frequency in the total word number of the annual report
	Artificial Intelligence Technology	AI	The proportion of word frequency of artificial intelligence technology in total word number of annual report
	Big Data Technology	BD	The proportion of word frequency of big data technology in total word number of annual report
	Cloud Computing Technology	CC	The proportion of cloud computing technology word frequency in total annual report word number

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Mechanism Variable	Blockchain Technology	BC	The proportion of blockchain technology word frequency in the total number of annual reports
	Digital Technology Application	ADT	The proportion of word frequency of digital technology application in total word number of annual report
	Absorptive capacity	AC	Annual R&D expenditure/operating income
Regulating Variable	Regional Digitization Level	RDL	Using entropy weight method, the digital output, fixed telephone penetration rate, mobile telephone penetration rate, Internet broadband penetration rate and number of web pages per capita were weighted to calculate the comprehensive index of regional digitalization level
Control Variable	Enterprise Scale	Size	The natural log of total assets
	Enterprise Age	Age	Ln (Year - year of listing +1)
	Revenue Growth Rate	Growth	(Revenue growth/total revenue of last year) ×100%
	Asset-liability Ratio	Lev	Total liabilities/total assets x 100%
	Cash Flow Ratio	Cash Flow	Net cash flow from operating activities/ending current liabilities
	Profitability	ROA	(Net profit/average total assets) ×100%
	Ownership Concentration Index 1(%)	TOP1	The proportion of the largest shareholder
	Board Size	Board	Ln (Number of Directors)
	Proportion of Independent Directors	Indep	(Number of independent directors/Number of directors) ×100%
	Dual Function	Dual	The combination of chairman and general manager is 1, otherwise it is 0
	Executive Ownership Ratio	M Share	Number of shares held by executives/total shares
	Executive Team Size	TMT Size	Ln (Number of executives)

Standard errors are in parenthesis. *** p < 0.01, ** p < 0.05, * p < 0.1.

3.3. Sample and Data Source

This paper takes A-share strategic emerging industry listed companies as the research sample, and the sample range is 2011-2021. To reduce the impact of extreme values on the conclusion, this article applies a 1% truncation to all continuous variables in the model. In the end, the total sample consisted of 1588 companies. The financial data of the companies used in this article are all from the

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CSMAR database. The digital transformation data of enterprises is obtained by using Python to capture all the annual report text data of listed companies. The ESG rating data of enterprises is sourced from the WIND database.

4. Empirical Results and Analysis

4.1. Descriptive Statistics

This article uses Stata17 software to conduct descriptive statistics on variables, and the results are shown in Table 2. It can be seen that the mean ESG of the explained variable is 4.03, with a maximum value of 7.75 and a minimum value of 0.5, indicating that there is a significant difference in ESG performance among different enterprises and the overall performance is relatively low. The mean of the natural logarithm of the core explanatory variable digital transformation is -12.3, indicating that a considerable number of enterprises have not yet undergone digital transformation, with a maximum value of -6.03966 and a minimum value of -18.42068. The overall level of digital transformation of enterprises is relatively low. In addition, descriptive statistics of control variables showed high consistency after comparing relevant literature [17].

Table 2. Descriptive statistics for each variable.

Variable	Obs	Mean	Std. dev.	Min	Max
ESG	11,682	4.0316	1.0973	0.5000	7.7500
DT	11,682	-12.3013	4.0074	-18.4207	-6.0397
AC	11,682	0.0689	0.0630	0.0000	0.3643
RDL	11,682	0.3687	0.1397	0.0933	0.6528
Size	11,682	21.9823	1.1605	19.8575	25.6465
Age	11,682	2.8346	0.3333	1.7918	3.4657
Growth	11,682	0.2102	0.3871	-0.4782	2.3539
Lev	11,682	0.3689	0.1888	0.0441	0.8157
CashFlow	11,682	0.0449	0.0647	-0.1362	0.2384
Roa	11,682	0.0513	0.0673	-0.2298	0.2497
Top1	11,682	0.3138	0.1373	0.0794	0.6873
Board	11,682	2.1064	0.1887	1.6094	2.5649
Indep	11,682	37.8100	5.3249	33.3300	57.1400
Dual	11,682	0.3355	0.4722	0.0000	1.0000
MShare	11,682	0.1791	0.2084	0.0000	0.7049
TMTSize	11,682	2.8115	0.1944	2.3979	3.3322

Standard errors are in parenthesis. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

4.2. Benchmark Regression

This paper uses Stata 17 software and OLS method (ordinary least square method) to estimate the coefficient (benchmark regression) of Equation (1) to examine the impact of digital transformation on enterprises' ESG performance. Table 3 shows the benchmark regression results of this paper. Columns (1) and (2) respectively represent the benchmark regression results and two-way fixed effect regression results after adding only the core explanatory variables of digital transformation, while columns (3) and (4) represent the benchmark regression results and two-way fixed effect regression results after adding control variables. Digital transformation has a positive promotion effect on the improvement of ESG performance at the confidence level of 10%. Therefore, the research hypothesis H1 is verified.

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Table 3. Benchmark regression results (core explanatory variables).

Variable	(1)	(2)	(3)	(4)
	ESG	ESG	ESG	ESG
DT	0.0201***	0.0160***	0.0180***	0.0133***
	(7.9729)	(3.8532)	(7.2885)	(3.3056)
Size			0.2644***	0.3053***
			(24.7852)	(9.3811)
Age			0.0296	-0.2475
			(0.9623)	(-1.4990)
Growth			-0.1073***	0.0287
			(-4.0747)	(1.1640)
Lev			-0.3582***	-0.2765**
			(-5.5434)	(-2.2707)
CashFlow			0.4510***	0.2048
			(2.7045)	(1.1489)
Roa			1.2754***	-0.5636***
			(7.1594)	(-2.8428)
Top1			0.2707***	0.7857***
			(3.7502)	(3.3929)
Board			0.0107	-0.3782**
			(0.1379)	(-2.5029)
Indep			0.0127***	0.0047
			(5.5940)	(1.2369)
Dual			-0.0930***	-0.0587
			(-4.3241)	(-1.5552)
MShare			0.3244***	0.7547***
			(6.1248)	(5.1429)
TMTSize			0.3095***	0.2939**
			(4.5873)	(2.2992)
Constant	4.2794***	4.0319***	-3.0586***	-2.3772***
	(130.9129)	(54.0189)	(-10.7682)	(-3.0019)
Observations	11,682	11,682	11,682	11,682
R-squared	0.0054	0.0284	0.0966	0.0610
code fe	no	yes	no	yes
year fe	no	yes	no	yes
Number of id	1588	1,588	1588	1,588

Standard errors are in parenthesis. *** p < 0.01, ** p < 0.05, * p < 0.1.

In addition, this paper further refines the explanatory variables into five sub-indicators, including artificial intelligence technology, big data technology, cloud computing technology, blockchain technology and digital technology, and introduces these five sub-indicators into the

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model for regression. The regression results are shown in Table 4. Big data technology and cloud computing technology have a more significant effect on promoting ESG performance of enterprises.

Table 4. Benchmark regression results (Subdivided explanatory variable).

Variable	(1)	(2)	(3)	(4)	(5)
	ESG	ESG	ESG	ESG	ESG
AI	0.0032				
	(0.0044)				
BD		0.0099*			
		(0.0040)			
CC			0.0150***		
			(0.0044)		
BC				0.0081	
				(0.0074)	
ADT					0.0059
					(0.0040)
_cons	-2.5282**	-2.3658**	-2.2894**	-2.4490**	-2.5115**
	(0.8020)	(0.7976)	(0.7943)	(0.8032)	(0.7934)
N	11682	11682	11682	11682	11682
r2	0.0597	0.0604	0.0612	0.0598	0.0599
F	23.2358	23.3905	23.3942	23.2236	23.3029
p	0.0000	0.0000	0.0000	0.0000	0.0000

Standard errors are in parenthesis. *** p < 0.01, ** p < 0.05, * p < 0.1.

4.3. Endogeneity Problem and Robustness Test

4.3.1. Endogeneity Problem

In order to solve the endogeneity problem, we adopt the propensity score matching PSM method and the multi-stage DID method to deal with it. First, this paper divides the sample enterprises into two groups according to whether the enterprises are undergoing digital transformation. Corresponding control variables are adopted as matching variables of PSM, and the nearest neighbor matching, radius matching and kernel matching methods are respectively adopted to find control enterprises for the enterprises in the treatment group. After passing the balance test, regression test was conducted on the matched samples, and the test results were shown in columns (1) to (3) of Table 5. The regression results show that digital transformation has a significant effect on enterprise ESG performance, and the core conclusions of this paper are robust and credible.

In addition, this paper regards the digital transformation behavior of the sample enterprises at different times as a quasi-natural experiment, and adopts the multi-phase DID method for testing and identification. The specific regression equations are shown in equations (4) and (5):

$$ESG_{it} = \beta_0 + \beta_1 du_{it} + dt_{it} + \sum_j \beta_j Controls + \lambda_i + \mu_t + \varepsilon_{it} \quad (4)$$

$$ESG_{it} = \beta_0 + \beta_1 du_{it} + dt_{it} \times DT_{it} + \sum_j \beta_j Controls + \lambda_i + \mu_t + \varepsilon_{it} \quad (5)$$

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Where, du is the virtual variable of the processing group, du=1 indicates that the enterprise has carried out digital transformation during the sample period, and du=0 indicates that the enterprise has carried out digital transformation during the sample period. dt is a time dummy variable, dt=1 when the processing group enterprises carry out digital transformation, dt=0 when the control group enterprises and the processing group enterprises do not carry out digital transformation. The empirical test results of multi-stage DID are shown in column (4) of Table 5. The key parameters to be estimated in the model are significantly positive at the level of 5%, that is, the core conclusions of this paper are still robust and credible after multi-phase DID model identification.

Table 5. Endogeneity test results.

Variable	PSM			DID
	(1)	(2)	(3)	(4)
	ESG	ESG	ESG	ESG
DT	0.0138**	0.0133**	0.0138**	
	(0.0043)	(0.0040)	(0.0043)	
DID				0.0742**
				(2.5400)
controls	YES	YES	YES	YES
code fe	YES	YES	YES	YES
year fe	YES	YES	YES	YES
_cons	-2.1427*	-2.3757**	-2.1427*	-2.6264***
	(0.8353)	(0.7924)	(0.8353)	(-3.3422)
N	9276	11672	9276	11,682
r2	0.0609	0.0611	0.0609	0.0604

Standard errors are in parenthesis. *** p < 0.01, ** p < 0.05, * p < 0.1.

4.3.2. Robustness Test

In this paper, in the robustness test, four methods are adopted, such as the hysteresis of the explained variable and the elimination of zero-value samples: Column (1) indicates that the explained variable is introduced into the model for regression with a lag of two periods as explanatory variable, and the model is changed to a dynamic model; column (2) indicates that the explained variable is still used as explanatory variable for regression with a lag of one period; Column (3) represents truncation of the core explanatory variable; column (4) indicates that zero samples of the core explanatory variable are eliminated. The results of the above four regressions are shown in Table 6. All four regressions pass the significance test at the 1% confidence level, indicating that the above results that prove that digital transformation can positively promote enterprise ESG performance are robust and credible.

Table 6. Robustness test results.

Variable	(1)	(2)	(3)	(4)
	ESG	L.ESG	ESG	ESG
L2.ESG	0.0532***			
	(0.0129)			

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DT	0.0123**	0.0144***		0.0474**
	(0.0039)	(0.0042)		(0.0171)
DT_w			0.0133***	
			(0.0040)	
controls	YES	YES	YES	YES
code fe	YES	YES	YES	YES
year fe	YES	YES	YES	YES
_cons	-1.1017	-1.2026	-2.3780**	-2.3018*
	(0.8266)	(0.8131)	(0.7919)	(0.9685)
N	8612	10094	11682	8429
r2	0.0617	0.0550	0.0610	0.0591
F	10.8219	17.1297	23.6177	15.6250
p	0.0000	0.0000	0.0000	0.0000

Standard errors are in parenthesis. *** p < 0.01, ** p < 0.05, * p < 0.1.

4.4. Mechanism Test and Regulatory Effect Test

According to formula (2) and Formula (3), the mediating and moderating effects of corporate absorptive capacity and regional digitalization level on the relationship between digital transformation and corporate ESG performance are tested. The empirical test results are shown in Table 7. In the mechanism test, the estimated parameters of core explanatory variables are significantly positive at the 1% confidence level, indicating that digital transformation can promote the positive improvement of ESG performance by improving the absorptive capacity of enterprises. In the moderating effect test, the parameters to be estimated in the cross-crossing term are significantly positive at the confidence level of 5%, indicating that regional digitalization level plays a positive moderating role between digital transformation and enterprise ESG performance. In summary, the research hypothesis H2 and H3a are verified, and the hypothesis is valid.

Table 7. Mechanism and regulatory effect test results.

Variable	**Mechanism Verification**		**Moderating Effect Test**
	(1)	(2)	（3）
	AC	ESG	ESG
DT	0.0004*	0.0127**	0.0151***
	(0.0002)	(0.0040)	(3.7286)
AC		1.4934**	
		(0.4658)	
RDL			0.5136
			(1.4443)
DT*RDL			0.0535**
			(2.1521)
controls	YES	YES	YES

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code fe	YES	YES	YES
year fe	YES	YES	YES
_cons	0.0900*	-2.5117**	-2.4950***
	(0.0369)	(0.7931)	(-3.1732)
N	11682	11682	11682
r2	0.1184	0.0636	0.0620
p	0.0000	0.0000	0.0000

Standard errors are in parenthesis. *** p < 0.01, ** p < 0.05, * p < 0.1.

4.5. Heterogeneity Analysis

In the heterogeneity analysis, the sample enterprises are divided into state-owned enterprises and non-state-owned enterprises according to property rights. Secondly, according to the classification standard of strategic emerging industries, the sample enterprises are divided into nine industries, such as the new generation of information technology industry and high-end equipment manufacturing industry. The regression results are shown in Tables 8 and 9. The empirical results show that, in both SOEs and non-SOEs, the promotion effect of digital transformation on ESG performance is significant at least at the 5% confidence level, and the promotion effect of digital transformation on ESG performance is more significant in SOEs. Among the nine industries, the promotion effect of digital transformation on enterprise ESG performance is more evident in high-end equipment manufacturing enterprises, and the impact of digital transformation on ESG performance is negative in the new generation of information technology industry. Analyze the reasons behind it, or the digital transformation degree of the new generation of information technology industry enterprises is higher, but the enterprise scale is smaller. Social visibility is low, and the performance of social responsibility is poor. In summary, the research hypothesis H3b and H3c are verified and the hypothesis is valid.

Table 8. Heterogeneity analysis regression Results (Property rights).

Variable	ESG(State-owned)	ESG(Private)
DT	0.0164***	0.0105**
	(3.0864)	(2.4165)
controls	YES	YES
code fe	YES	YES
year fe	YES	YES
_cons	-1.5428	-3.1860***
	(-1.4689)	(-4.7082)
N	2,926	8379
r2	0.0869	0.0721

Standard errors are in parenthesis. *** p < 0.01, ** p < 0.05, * p < 0.1.

Table 9. Heterogeneity analysis Regression Results (Industry).

Variable	(1)	(2)	(3)	(4)	（5）
	The new generation of information	High end equipment manufacturing industry	New materials industry	Biological industry	New energy vehicle industry

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	technology industry				
	ESG	ESG	ESG	ESG	ESG
DT	-0.0051	0.0240**	0.0104	0.0160*	0.0750*
	(0.0075)	(0.0089)	(0.0081)	(0.0074)	(0.0301)
controls	YES	YES	YES	YES	YES
code fe	YES	YES	YES	YES	YES
year fe	YES	YES	YES	YES	YES
_cons	-1.9721*	-2.7688	-2.2656	-4.4945**	-16.3140
	(0.8917)	(1.5179)	(1.6031)	(1.4076)	(8.5966)
N	3817	1688	1568	1842	136
r2	0.0753	0.0671	0.0891	0.0896	0.4395

Variable	**(6)**	**（7）**	**（8）**	**（9）**
	New energy industry	Energy conservation and environmental protection industry	Digital creative industry	Related service industry
	ESG	ESG	ESG	ESG
DT	0.0130	0.0252*	0.0325	0.5608
	(0.0102)	(0.0118)	(0.0220)	(0.6900)
controls	YES	YES	YES	YES
code fe	YES	YES	YES	YES
year fe	YES	YES	YES	YES
_cons	-2.7086	-5.6682*	-1.4455	27.9815
	(1.7140)	(2.3335)	(2.7648)	(24.2249)
N	1276	853	461	41
r2	0.0762	0.1427	0.1447	0.8442

Standard errors are in parenthesis. *** p < 0.01, ** p < 0.05, * p < 0.1.

5. Conclusions

This paper takes 1,588 A-share listed companies in strategic emerging industries as research samples, selects the sample companies' ESG rating data, digital transformation data and related financial data from 2011 to 2021 as sample data, and adopts the two-way fixed effect model to conduct an empirical study on the impact of digital transformation on ESG performance of sample enterprises and its mechanism. The moderating effect of regional digitization level on the relationship between digital transformation and ESG performance was investigated, and the sample firms were further subdivided according to property rights and industries for heterogeneity analysis.

The empirical results show that: 1. Digital transformation can positively promote the improvement of enterprise ESG performance, and this conclusion is still valid after a series of endogenous and robust tests; 2. Heterogeneity analysis shows that digital transformation has a differentiated impact on the improvement of ESG performance of enterprises, and the effect of digital transformation on the improvement of ESG performance of enterprises is more significant in state-owned enterprises and high-end equipment manufacturing enterprises; 3. Digital transformation can promote the improvement of ESG performance by improving absorptive capacity of enterprises,

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which indicates that improving absorptive capacity is a key way for digital transformation to promote the improvement of ESG performance of enterprises, which is conducive to enterprises to obtain long-term competitive advantages and achieve sustainable development; 4. Regional digitalization level plays a positive moderating role between digital transformation and ESG performance of enterprises. A good regional digitalization level is a strong support for enterprises to promote digital transformation and thus improve their ESG performance.

6. Discussion

In view of the above empirical conclusions, relevant departments and units can consider the following aspects to improve enterprise ESG performance:

Enterprises: ① Take digital transformation as the long-term development strategy of enterprises. In the era of digital economy, technological changes are rapid and frequently. In order to obtain long-term competitive advantages, enterprises need to take enterprise digital transformation as a long-term development strategy to achieve sustainable development in the current fierce market competition. In order to achieve sustainable development, enterprises need to take digital transformation as a long-term development strategy to achieve sustainable development in the current fierce market competition. Moreover, the research shows that the digital transformation of state-owned enterprises and high-end equipment manufacturing enterprises can significantly improve the ESG performance of enterprises, and each enterprise should formulate differentiated development strategies after fully considering its own situation. ②Strengthen the cultivation of absorptive capacity. According to the research conclusions, the digital transformation of enterprises can promote the improvement of ESG performance by strengthening the absorptive capacity of enterprises. ③Strengthen friendly contact and interaction with the government. The level of regional digitalization has a profound impact on the process of enterprise digital transformation.

Government: ①Improve the construction of regional digital infrastructure and narrow the difference in regional digital level. The management department should constantly improve the construction of digital infrastructure, enhance the regional digital level, and narrow the regional digital level difference as much as possible, so as to provide more comprehensive supporting services for the digital transformation of enterprises. ②Strengthen support for digital transformation of non-state-owned enterprises. Relevant departments should increase policy and financial support for the digital transformation of non-state-owned enterprises, adopt differentiated policies for enterprises in different industries, and realize the comprehensive promotion of enterprise digital transformation.

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