

Corporate Digital Transformation and ESG Performance

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Abstract. This study utilizes panel data from China's A-share listed companies (2012–2024) to investigate the relationship between digital transformation and corporate ESG performance. The results demonstrate that digital transformation substantially improves ESG outcomes, a finding that remains robust across multiple sensitivity tests. Mechanism analysis reveals that digitalization enhances ESG performance primarily by stimulating green technology innovation. This innovation facilitates optimized resource utilization and a reduction in environmental footprints. Furthermore, public environmental concern acts as a positive moderator, strengthening the beneficial impact of digital transformation on ESG by applying external pressure on firms. Theoretically, this research contributes to the literature on digitalization and ESG by uncovering the mediating role of green innovation and the interactive effect of public environmental sentiment. The study concludes that digital transformation represents a viable pathway for elevating corporate ESG performance, with green innovation and heightened public environmental attention serving as key drivers. These findings offer valuable theoretical insights and practical implications for policymakers promoting digital technology adoption and for businesses pursuing sustainable development goals.

Keywords: digital transformation, ESG performance, green technology innovation, public environmental concern

1. Introduction

ESG performance has become a pivotal measure of corporate value, significantly shaping investment choices and stakeholder confidence. Simultaneously, global investment in digital transformation has surged, exceeding \$2.1 trillion in 2023 and projected to reach \$4.4 trillion by 2028, highlighting the imperative to examine its nexus with ESG. As the world's largest emerging economy, China offers a compelling research setting due to its "Dual Carbon" objectives and digital economy strategy, providing valuable insights for comparable developing nations. The pertinence of this investigation is amplified by the A-share market's status as the world's second-largest by capitalization, coupled with the fact that only 45.67% of its constituent firms disclosed ESG data in 2024.

This study analyzes the impact of digital transformation on ESG performance using data from Chinese A-share listed companies spanning 2012–2024. The results demonstrate that digital transformation exerts a significant positive effect on ESG performance. Crucially, green technology

innovation is identified as a primary mediating channel through which this enhancement occurs. Furthermore, public environmental concern acts as a positive moderator, reinforcing the relationship between digital transformation and ESG outcomes. Heterogeneity analysis reveals that the beneficial impact is more salient for firms operating in heavily polluting industries, those facing lower financing constraints, and state-owned enterprises (SOEs). Collectively, these findings indicate that digital transformation principally drives ESG improvement by fostering green innovation, with public scrutiny amplifying this dynamic. They underscore the strategic importance of digitalization for sustainable development, particularly for high-pollution sectors and firms with greater resource access.

Building upon prior research [1] linking digital transformation to improved ESG via enhanced green innovation, social responsibility fulfillment, and governance effectiveness—especially under heightened climate risk, in high-carbon sectors, and non-pilot zones—this research offers distinct contributions. It systematically investigates the mediating function of green innovation technologies and the moderating role of public environmental concern within the digital transformation-ESG relationship. Additionally, it constructs a nuanced heterogeneity framework based on pollution intensity, financing constraints, and ownership structure. This approach enriches the existing literature by elucidating the mechanism through which digital transformation elevates ESG via green technologies and by providing deeper contextual insights through heterogeneity analysis. The study thus delivers significant theoretical value, emphasizing the critical roles of eco-innovation capabilities and contingent factors in enabling sustainable corporate development within the digital era.

1.1. The impact of corporate digital transformation on ESG compliance

Corporate digitalisation enhances ESG performance through synergies across environmental (E), social (S), and governance (G) dimensions. Environmentally, digital tools optimise resource use [2], reduce waste, and lower ecological footprints. Socially, digitalisation enhances stakeholder transparency and trust while improving employee well-being through remote work. In governance, data analytics integrate stakeholder feedback (e.g., complaints, sentiment) to refine ESG strategies. Studies confirm digital transformation positively correlates with ESG performance under comparable conditions [1]. Advanced data technologies further drive ESG commitments by enabling green innovation, creating jobs, and strengthening internal controls [3]. Consequently, digital transformation elevates ESG performance via multidimensional synergies and data-driven decisions. Thus, the hypothesis is proposed:

H1: Enterprise digitalisation can promote corporate ESG compliance performance.

1.2. The mediating role of green technology innovation

Corporate digital transformation enhances ESG performance primarily through green technology innovation [4]. By integrating technologies like IoT and AI, enterprises optimize resource allocation, reduce waste, and enable green technology R&D. Digital transformation also mitigates information asymmetry, strengthening green innovation capacity and improving environmental outcomes [5]. These innovations boost resource efficiency while minimizing environmental harm, elevating corporate carbon performance and advancing sustainability goals.

Governance optimization forms another key mechanism. Green technology innovation fosters robust ESG management systems and disclosure frameworks, refining corporate governance. Digital tools facilitate transparent reporting, streamline decision-making, and ensure accountability.

Consequently, digital transformation delivers dual benefits: improving economic performance through operational efficiency and reducing environmental footprints. This synergy between technological advancement and governance refinement highlights digitalization's role in balancing profitability with environmental responsibility. The findings indicate that digital transformation unlocks significant ESG gains, creating a business-environment win-win. Thus, the study hypothesizes:

H2: Green technology innovation mediates the relationship between digital transformation and ESG performance.

1.3. The moderating role of public environmental concern

Rising public environmental concern strengthens the positive effect of corporate digitalization on ESG performance. Heightened awareness encourages governments to implement policies promoting digital transformation, lowering institutional ESG costs [6]. Concurrently, the ESG improvements achieved via digitalization build reputational capital, attracting green investors and easing financing constraints [7]. This dual benefit facilitates aligning digital strategies with ESG goals.

Furthermore, external stakeholders—public, media, investors—act as a vital regulatory force. Sustained pressure compels firms to prioritize allocating digital resources (technology, funding, talent) to ESG initiatives [8]. Digital tools like ESG platforms, green supply chain systems, and energy optimization technologies help firms systematically enhance ESG performance. These actions address stakeholder demands and reduce regulatory risks. Thus, the interaction between public environmental consciousness and corporate digitalization fosters a sustainable ecosystem where technology and ESG compliance mutually reinforce each other. Consequently, we hypothesize:

H3: Public environmental concern positively moderates the relationship between digital transformation and ESG performance.

1.4. Data source and processing

This research examines Chinese A-share listed firms spanning 2012 to 2024. To ensure data integrity, the sample underwent rigorous processing: excluding ST and *ST companies, financial institutions, and observations with incomplete data. Continuous variables were winsorized at the 1st and 99th percentiles to reduce the impact of outliers. Data were principally obtained from the CSMAR database and the Baidu Index website. This thorough methodology strengthens the analysis's credibility and robustness.

1.5. Model setting

This paper tests the impact of firms' digital transformation on ESG performance according to model (1). Where the subscripts i and t denote the sample individuals and years, respectively. The explanatory variable $ESG_{i,t}$ reflects the ESG performance of i firms in year t . The core explanatory variable $lnDT_{i,t}$ captures the extent of digital transformation of i firms in year t , and $Controls_{i,t}$ is a series of control variables. The model fixes both year fixed effects at $year$ and industry fixed effects at ind , with $\varepsilon_{i,t}$ as a random disturbance term. If the regression coefficient of $lnDT_{i,t}$ β_1 is significantly positive, it indicates that digital transformation has a facilitating effect on firms' ESG performance; if the coefficient is negative, it indicates that digital transformation has a dampening effect on firms' ESG performance.

$$ESG_{i,t} = \beta_0 + \beta_1 \ln DT_{i,t} + \beta_2 \text{Controls}_{i,t} + \text{Ind}_j + \text{Year}_t + \varepsilon_{i,t} \quad (1)$$

This part tests the mediating effect of green technology innovation on digital transformation and ESG performance according to models (2) and (3). Where $GTI_{i,t}$ denotes the green technology innovation performance of enterprises. If α_1 and φ_2 are significant, it indicates that green technology innovation has a mediating role. Further, if φ_1 is significant, it indicates that there is a partial mediation effect; conversely, if φ_1 is not significant, it indicates that green technology innovation plays a complete mediation effect.

$$GTI_{i,t} = \alpha_0 + \alpha_1 \ln DT_{i,t} + \alpha_2 \text{Controls}_{i,t} + \text{Ind}_j + \text{Year}_t + \varepsilon_{i,t} \quad (2)$$

$$ESG_{i,t} = \varphi_0 + \varphi_1 \ln DT_{i,t} + \varphi_2 GTI_{i,t} + \varphi_3 \text{Controls}_{i,t} + \text{Ind}_j + \text{Year}_t + \varepsilon_{i,t} \quad (3)$$

This part tests the moderating role of public environmental concern on digital transformation and ESG performance according to model (4). Where $Baidu_Index_{i,t}$ is used to measure public environmental concern. If the coefficient γ_3 is significant, it indicates that public environmental concern significantly moderates the impact of corporate digital transformation on ESG performance.

$$ESG_{i,t} = \gamma_0 + \gamma_1 \ln DT_{i,t} + \gamma_2 Baidu_Index_{i,t} + \gamma_3 (\ln DT_{i,t} \times Baidu_Index_{i,t}) + \gamma_4 \text{Controls}_{i,t} + \text{Ind}_j + \text{Year}_t + \varepsilon_{i,t} \quad (4)$$

1.6. Description of variables

1.6.1. Digital transformation

This study measures enterprise digital transformation level ($\ln DT$) using the method described in [9]. Corporate annual reports are analyzed via text analysis with Python, extracting relevant data and counting feature word occurrences. These frequencies are categorized, summed, and formed into a composite index. The final $\ln DT$ metric is obtained after logarithmic transformation, enabling cross-firm comparability. This approach offers a systematic, quantifiable assessment of digital transformation.

1.6.2. ESG performance

ESG performance assesses corporate sustainability across environmental, social, and governance dimensions. The explanatory variable ESG utilizes the [Hua Zheng ESG rating system], which classifies companies into nine tiers ranging from AAA to C. These ratings are converted into a descending numerical scale from 1 (lowest) to 9 (highest). Consequently, a higher score signifies superior ESG performance and reflects more robust sustainable development practices. This rating offers a standardized metric for evaluating corporate responsibility and long-term value creation.

1.6.3. Green technology innovation

To measure green technology innovation, this study employs corporate green patent applications as the proxy variable. Following [10], we address data "right-skewness" by adding 1 to the original values and applying the natural logarithm. This transformation promotes a more normal distribution, enhances analytical robustness, and ensures cross-study comparability.

1.6.4. Public environmental concerns

This research utilizes the methodology outlined in reference [11] to quantify regional public environmental concern. We implement Python-based web crawlers to gather annual Baidu search data (PC and mobile) at the prefecture-city level, using "environmental pollution" as the target keyword. This collected data is subsequently matched with listed companies' registered addresses. The search volume undergoes normalization via the natural logarithm. Finally, we construct the moderating variable $Baidu_Index_{i,t}$ as a proxy for annual regional public environmental awareness, capturing its local spatiotemporal variations.

1.6.5. Control variables

To mitigate confounding effects, this analysis includes several firm-specific controls: size (lnSize), financial leverage (Lev), profitability (ROA), operating cash flow (Cash), growth opportunities (Growth), firm age (Age), and managerial ownership (Mshare). Variable definitions are detailed in Table 1. These controls isolate the relationship between the primary explanatory variables and the outcomes of interest.

Table 1. Variable definitions

Variable Type	Variable name	Variable symbol	Variable Definition
Explained variable	ESG Performance	ESG	CSI ESG Rating Index
Explanatory Variables	Digital Transformation	lnDT	Natural logarithm of the total digitised word frequency plus one in the textual content of the company's annual report
Mediating Variables	Green Technology Innovation	GTI	Natural logarithm of the number of green patent applications plus 1
Moderator variable	Public Environmental Concern	Baidu_Index	Natural logarithm of Baidu_Index plus 1 for "environmental pollution".
Control Variables	Firm size	lnSize	Natural logarithm of year-end total assets
	Financial leverage	Lev	Ratio of a firm's total liabilities at year-end to its total assets at year-end
	Profitability	ROA	Ratio of the enterprise's net profit for the year to its net assets at the end of the year
	Operating Cash Flow	Cash	Net cash flow from operations
	Growth	Growth	The growth rate of current year's revenue relative to the previous year's revenue.
	Age	Age	The natural logarithm of the number of years the enterprise has been listed
	Mshare	Mshare	Ratio of management's shareholding to total shareholding at the end of the year

2. Empirical analysis

2.1. Descriptive statistics

Table 2 presents descriptive statistics for key variables. Corporate ESG performance (ESG) averages 4.070 (SD=1.020), ranging from 1 to 7.250. This distribution suggests overall mid-upper level ESG performance among sample firms, aligning with existing literature [12]. Notably, significant disparities exist, with some enterprises lagging considerably behind industry leaders. The digital transformation measure (lnDT) shows a mean of 1.990 (SD=1.620), spanning 0 to 6.960, indicating substantial divergence in digitalization progress. This bifurcation likely reflects variations in industry sector, firm size, and regional policy support, consistent with findings [1]. Descriptive statistics for other control variables also correspond with established research.

Table 2. Descriptive statistics of main variables

Variable	N	Mean	SD	Min	p50	Max
ESG	5463	4.070	1.020	1	4	7.250
lnDT	5463	1.990	1.620	0	1.950	6.960
lnSize	5463	22.55	1.300	17.76	22.43	27.51
Growth	5463	0.0700	0.470	-25.30	0.100	1
Age	5463	2.240	0.870	0	2.480	3.500
ROA	5463	0.0300	0.0800	-1.860	0.0300	0.790
Mshare	5463	0.100	0.170	0	0	0.750
Lev	5463	2.630	80.93	-0.0100	0.0300	3814
Cash	5463	19.52	1.650	10.51	19.50	24.75
GTI	5463	0.200	0.400	0	0	1.920
Baidu Index	5463	64.99	38.25	0.620	67.33	140.4
Is heavy p~r	5463	0.310	0.460	0	0	1
Is financi~d	5463	0.470	0.500	0	0	1
Is soe	5463	0.390	0.490	0	0	1

2.2. Benchmark empirical results

Table 3, Column (1) indicates a significantly positive coefficient (0.0318) for digital transformation (lnDT) at the 1% level. This implies that a 1% increase in digital transformation level corresponds to an approximate 0.0318% rise in firms' ESG performance, offering initial support for the study's theoretical hypotheses.

Table 3. Benchmark regression and robustness test

	(1) ESG	(2) ESG
lnDT	0.0318*** (0.0104)	
DIGI_text		2.214*** (0.727)
lnSize	0.252*** (0.0187)	0.254*** (0.0186)
Growth	0.0365 (0.0280)	0.0373 (0.0280)
Age	-0.236*** (0.0198)	-0.234*** (0.0198)
ROA	1.648*** (0.174)	1.643*** (0.174)
Mshare	0.129 (0.0967)	0.139 (0.0965)
Lev	0.000223 (0.000155)	0.000221 (0.000155)
Cash	0.000684 (0.0137)	0.00171 (0.0137)
year	Yes	Yes
ind	Yes	Yes
_cons	-2.040*** (0.327)	-2.061*** (0.326)
N	5175	5175
R ²	0.203	0.203
adj. R ²	0.190	0.190

* p < 0.1, ** p < 0.05, *** p < 0.01

2.3. Robustness test

Drawing on literature [13]'s methodology to avoid bias from singular measures, this study substitutes enterprise digitization (DIGI_text) as the explanatory variable to assess its impact on ESG performance. The results reveal a significantly positive regression coefficient (1% level) for enterprise digitization on ESG performance. This demonstrates that digitization's enhancing effect holds across different measurement approaches, confirming the robustness of our findings.

2.4. Mechanism test

2.4.1. Mediation effect test

Based on Columns (1) and (2) in Table 4 examining the mediating effect of green technology innovation, the results demonstrate that enterprise digital transformation significantly enhances green technology innovation at the 1% level (coefficient = 0.0147). This indicates a 0.0147% increase in green innovation for every 1% rise in digital transformation intensity. Column (2) further reveals that while digital transformation maintains a significant direct effect on ESG performance, green technology innovation acts as a partial mediator in this relationship. Consequently, digital transformation improves ESG performance partly by boosting green innovation capability, supporting Hypothesis H2.

Table 4. Mediating effect test and moderating effect test

	(1) GTI	(2) ESG	(3) ESG
lnDT	0.0147***	0.0282***	-0.0181 (0.0181)
Baidu_Index	(0.00408)	(0.0104)	-0.000406 (0.000566)
lnSize	0.0784*** (0.00732)	0.233*** (0.0188)	0.252*** (0.0187)
Growth	-0.00794 (0.0110)	0.0385 (0.0279)	0.0396 (0.0280)
Age	-0.0283*** (0.00775)	-0.229*** (0.0197)	-0.232*** (0.0198)
ROA	0.159** (0.0681)	1.608*** (0.173)	1.622*** (0.174)
Mshare	-0.00223 (0.0378)	0.130 (0.0963)	0.121 (0.0968)
Lev	-0.0000647 (0.0000606)	0.000239 (0.000154)	0.000231 (0.000155)
Cash	0.00118 (0.00536)	0.000390 (0.0136)	0.00205 (0.0137)
year	Yes	Yes	Yes
ind	Yes	Yes	Yes
c.lnDT#c.Baidu_Index			0.000705*** (0.000219)
_cons	-1.640*** (0.128)	-1.631*** (0.331)	-2.020*** (0.328)
N	5175	5175	5175
R ²	0.194	0.210	0.205
adj. R ²	0.181	0.197	0.192

2.4.2. Moderating effects test

Column (4) of Table 4 reveals a significant positive moderating effect of public environmental concern. The coefficient for the interaction term ($\ln DT_{i,t} \times \text{Baidu_Index}_{i,t}$) is 0.000705, significant at the 1% level. This indicates that heightened public environmental concern strengthens the positive relationship between corporate digital transformation and ESG performance. Consequently, Hypothesis H3, proposing this positive moderation, is supported.

2.5. Heterogeneity test

Research demonstrates that corporate digital transformation substantially improves ESG performance. Heterogeneity analysis indicates the impact varies across three dimensions: pollution levels, financing constraints, and ownership structures. These findings underscore the complex link between digital adoption and sustainable development, with particularly pronounced effects in heavily polluting industries and state-owned enterprises with greater financial constraints.

2.5.1. Pollution degree

Based on industry classification, the sample is categorized into heavily polluting and non-heavily polluting enterprises. Columns (1) and (2) of Table 5 demonstrate that digital transformation significantly enhances the ESG performance of heavily polluting enterprises more than that of non-heavily polluting enterprises, significant at the 1% level. This indicates that applying digital technology can improve the pollution control capacity of heavily polluting firms, directly boosting their environmental performance and consequently elevating their overall ESG performance.

2.5.2. Financing constraints

Based on the research methodology outlined in existing literature [14], this study employs the absolute value of the SA index to measure the extent of ultra-high corporate financing constraints. The sample is divided into high and low financing constraint groups using the median value. Regression results in columns (3) and (4) of Table 5 demonstrate that the impact of digital transformation on corporate ESG performance is more pronounced in firms facing low financing constraints compared to those with high constraints. Specifically, the regression coefficients for digital transformation ($\ln DT$) are statistically significant at the 5% level and larger in magnitude for low-constraint firms. This indicates that the positive contribution of digital transformation to ESG performance is more significant when financing constraints are lower. This finding suggests that financing constraints limit corporate cash flows, hindering sufficient financial support for digital transformation initiatives and thereby weakening its enhancing effect on ESG performance. Moreover, a negative correlation exists between the degree of financing constraints and the ESG improvement driven by digital transformation.

2.5.3. Property attributes

The sample is categorized into state-owned enterprises (SOEs) and non-state-owned enterprises (NSOEs). Table 5, columns (5) and (6), show differential impacts of digital transformation on ESG performance between these groups. For SOEs, digital transformation's positive effect on ESG is statistically significant at the 1% level. In contrast, the coefficient for NSOEs is significant only at the 5% level. This indicates that digital transformation more substantially enhances ESG

performance in SOEs. The divergence stems from several reasons. Firstly, SOEs encounter heightened regulatory oversight on environmental and social obligations, motivating more effective use of digital technologies to improve ESG outcomes. Secondly, facing greater public and governmental pressure, SOEs prioritize digital initiatives aligned with ESG requirements, leading to larger ESG gains relative to NSOEs.

Table 5. Heterogeneity analysis

	(1)	(2)	(3)	(4)	(5)	(6)
	ESG	ESG	ESG	ESG	ESG	ESG
lnDT	0.0196 (0.0205)	0.0371*** (0.0120)	0.0362** (0.0141)	0.0240 (0.0153)	0.0410** (0.0184)	0.0354*** (0.0125)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
year	Yes	Yes	Yes	Yes	Yes	Yes
ind	Yes	Yes	Yes	Yes	Yes	Yes
_cons	-0.542 (0.591)	-2.690*** (0.368)	-1.616*** (0.397)	-1.747*** (0.611)	-1.742*** (0.525)	-1.403*** (0.434)
N	1668	3507	2516	2659	1992	3183
R ²	0.129	0.251	0.261	0.221	0.282	0.227
adj. R ²	0.112	0.237	0.236	0.197	0.255	0.207

*p < 0.1, **p < 0.05, ***p < 0.01

3. Conclusions and recommendations

The study shows that corporate digitalization substantially improves ESG performance. A 1% rise in digitalization correlates with a 0.0318% increase in ESG scores, demonstrating digital technology's transformative role in promoting sustainable business. Mechanism analysis reveals digitalization mainly enhances ESG by enabling green technology innovation, as digital tools streamline the research, development, and implementation of eco-friendly solutions. Additionally, public environmental concern positively moderates this relationship, strengthening the link between digitalization and ESG gains. Heterogeneity analysis indicates digitalization's benefits are stronger in heavily polluting industries, state-owned enterprises, and firms with lower financing constraints, suggesting resources and institutional contexts are vital for maximizing digital transformation's ESG impact.

To capitalize on these findings, businesses should accelerate their digital transition while integrating ESG objectives into their strategic frameworks. Establishing dedicated ESG task forces can ensure systematic oversight and implementation of sustainability initiatives, while dynamic environmental performance disclosures and third-party certifications can enhance transparency and credibility. Governments, on the other hand, should design targeted policies to incentivize digital and green synergies, such as tax breaks, subsidies, and low-interest loans for firms adopting ESG-aligned digital practices. Incorporating ESG metrics into corporate digitalization assessments could further align technological progress with sustainability goals. Additionally, creating public funding mechanisms, such as green technology R&D grants, would encourage firms to pursue patents for eco-friendly innovations. Regulatory approaches should be tailored to industry-specific needs:

stringent ESG disclosure requirements for high-pollution sectors must be coupled with support for their transition through green innovation, ensuring compliance without stifling growth.

Ultimately, the interplay between digitalization and ESG performance offers a pathway to achieving "dual dividends" in societal welfare and ecological conservation. By leveraging digital tools to advance green innovation and responding to public environmental expectations, firms can simultaneously boost competitiveness and sustainability. Policymakers must adopt a nuanced approach, balancing incentives with regulatory pressures to address disparities across industries and ownership structures. This dual focus on technological advancement and environmental stewardship can unlock long-term value for businesses, society, and the planet, aligning economic growth with the principles of sustainable development.

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