Mechanism of the Impact of Enterprise Digital Transformation on ESG Performance from Internal and External Perspectives

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Abstract. With the full arrival of the digital economy era and the growing prominence of sustainable development concepts, Digital Transformation and ESG have garnered widespread attention across society. This study uses A-share listed companies from 2013 to 2023 as its research sample, adopting an Internal Control and External Supervision perspective to construct a dual fixed-effects model. It empirically investigates the relationship and underlying mechanisms between DT and ESG Performance. The findings reveal: (1) DT can help companies improve their ESG Performance, and this finding withstands an extensive battery of robustness checks. (2) Internal Control and External Supervision play a partial mediating role between DT and ESG Performance, indicating that DT promotes corporate sustainability through both internal and external pathways. (3) Heterogeneity analysis shows that the promotional effect of DT on ESG is more pronounced in eastern regions and non-state-owned enterprises, while the marginal effects in central and western regions and state-owned enterprises are relatively limited. The article provides theoretical basis for understanding the intrinsic mechanisms driving ESG improvement through digital technology and offers decision-making references for policy formulation and corporate practice.

Keywords: Digital Transformation, ESG Performance, Internal Control, External Supervision, Intermediary Effect.

1. Introduction

During the process of China's economic transformation from high - speed growth to high - quality development, particularly since the “dual carbon” goals were proposed at the United Nations General Assembly in September 2020, there has been unprecedented attention from various social sectors toward corporate sustainability and ESG principles. The China Securities Regulatory Commission (CSRC) is currently developing ESG disclosure rules for Chinese listed companies to strengthen corporate ESG responsibility fulfillment. ESG is an emerging investment and management philosophy first introduced in the 2004 Global Compact[1]. It requires companies to operate sustainably across three dimensions: environment, social, and governance. While investors and companies pursue profits, they must also place high priority on non-financial performance to maximize social value. Under policy guidance and practice-oriented approaches, implementing ESG principles has become an inevitable path for corporate high-quality development. How to enhance ESG responsibility fulfillment capabilities has emerged as an unavoidable issue for corporate high-quality development. Meanwhile, China's digital economy reached a scale of 45.5 trillion yuan in 2021. It witnessed a 16.2% year - on - year increase, represented 39.8% of GDP and has already established a significant position in the national economy. The “Overall Plan for the Construction of a Digital China” released in 2023 proposes “to fully empower socio-economic development, strengthen and optimize the digital economy, cultivate and expand the core industries of the digital economy, drive the convergence of digital technology and the real economy, and support the development and advance of digital enterprises”[2]. This guiding plan has comprehensively accelerated the DT process across all industries. Therefore, examing the correlation between DT and ESG Performance holds significant practical significance.

Following the emergence and extensive use of ESG, some scholars have conducted extensive theoretical and empirical research on the topic, but there are still shortcomings. First, compared to research focusing on the consequences of corporate ESG, studies on the mechanisms and pathways to improve corporate ESG Performance have started relatively late, with most focusing on individual dimensions within ESG[3]. For example, Li Xin et al. found that public environmental demands are a significant driving force compelling companies to improve their environmental performance[4]. Xiao Hongjun et al. pointed out that corporate digitalization can effectively drive corporate social responsibility forward, and this significantly uplifts corporate social responsibility performance.[5]. Subsequent scholars gradually recognized the holistic nature of these three dimensions and redirected their research efforts from analyzing corporate performance in separate dimensions towards evaluating the overall ESG performance of corporates.[3]. Second, while Liu Shuchun et al. argue that the fundamental restructuring of management approaches and operational mechanisms brought about by DT will inevitably provide companies with new resources and capabilities, Zeng Fuyu et al. contend that the swift advancement of digital technology offers a mixed bag of opportunities and challenges for companies aiming to attain sustainable development.[6][7]. On one hand, digital technology increases resource consumption, while on the other hand, it provides impetus for sustainable development. Therefore, there is still no clear answer on whether companies can coordinate the resources, abilities, and competitive strengths conferred by DT with the long - term aim of sustainable development. Furthermore, at the mechanism level, current research primarily focuses on individual dimensions, with limited comprehensive and systematic studies examining the channels via which DT affects ESG Performance from an integrated perspective. For instance, Li Fang et al. argue that reducing agency costs enables DT to enhance ESG Performance.[8]. Duan Aohan argues that DT can boost a company's ESG Performance through green technological innovation [9].

Given this, this paper utilizes data from Chinese A-share listed companies from 2013 to 2023 to examine the impact of DT on corporate ESG Performance, further explore its underlying mechanisms, and propose relevant policy recommendations to assist companies in improving their ESG Performance. The potential contributions of this paper are as follows: First, this paper examines the impact of DT on corporate ESG Performance from both internal and external perspectives, identifying two influence pathways—analyst attention and internal information transparency—thereby expanding the scope of research on the impact of DT on ESG. Second, this paper explores the impact of DT on the ESG Performance of companies in different regions and with different ownership structures, providing empirical evidence to support tailored approaches to promoting DT and differentiated strategies for enhancing corporate ESG Performance.

2. Theoretical Analysis and Research Hypotheses

2.1. Digital Transformation and ESG Performance

Jensen, M. C. argues that maximizing shareholder value is the core objective of a company[10]. However, Freeman, R. E. et al. propose the “power of harmony” framework, which suggests that companies must simultaneously cater to the demands of shareholders, employees, communities, and the environment, aligning with ESG development principles[11]. DT can promote corporate growth[12]. After leveraging digital technology to enhance production efficiency and operational management levels to meet economic interests, companies are more willing to fulfill their social missions.

DT helps enhance corporate core capabilities[13]. Under the empowerment of digital technology, DT has driven the service-oriented transformation of businesses, enhancing their service awareness and increasing their focus on brand image and external reputation, thereby improving their performance in environmental and social responsibility[14]. DT enables businesses to reconfigure and streamline production resources, enhance efficiency and attain superior results within the current scope of innovation resources.[15]. The systemic changes brought about by DT have reshaped

business models, streamlined business processes, reduced costs, and created more flexible employment opportunities for society, thereby driving sustainable economic growth[16].

Exploring the impacts of DT from an Internal Control perspective, on one hand, digital technologies can enhance Internal Control efficiency through standardized processes, reduce agency costs and information asymmetry, and improve corporate governance capabilities and ESG Performance[17]. On the other hand, digital technologies facilitate internal information sharing and external information penetration, enabling proactive and rapid prevention of ESG risks and enhancing ESG Performance. From an External Supervision perspective, DT attracts analysts' attention to the company, compelling management to improve ESG Performance. Additionally, DT drives advancements in the quality of corporate information disclosure, with analyst attention attracting more resources to the company, thereby facilitating corporate ESG [18].

Based on the above analysis, this paper proposes the hypothesis H1 in Figure1: Digital Transformation can improve a company's ESG responsibility performance.

2.2. The mediating role of Internal Control

To begin with, the efficiency of Internal Control can be effectively improved and the vulnerabilities due to human intervention can be reduced by automated processes backed by digital technology. By standardizing data collection and verification processes, the risk of "greenwashing" is reduced, and internal information transparency is enhanced[17]. This effectively cuts down information asymmetry between the organization and its stakeholders, providing external stakeholders with reliable decision-making basis, thereby prompting the effectiveness of the company's external governance mechanisms and forming an effective constraint on internal controllers such as shareholders and management. This significantly enhances the company's governance capabilities and contributes to the enhancement of corporate ESG Performance.

Secondly, companies are able to utilize technologies like big data and cloud computing in real-time, dynamically mine external market demand, clarify the latest social norms and environmental protection requirements[19]. They can also dynamically capture internal ESG-related risks (such as environmental violations and supply chain ethical issues), enabling companies to shift their Internal Controls from passive compliance to proactive prevention, thereby promoting improvements in corporate ESG Performance.

Thirdly, by integrating and sharing data assets across the entire organization, companies can break down systemic data barriers and achieve data sharing[20]. This ensures the authenticity and completeness of ESG data, enhances internal information transparency, enables continuous monitoring and rapid rectification of ESG risks, and contributes to the enhancement of corporate ESG Performance.

Therefore, this paper proposes the hypothesis H2 in Figure1: Digital Transformation can enhance internal information transparency, improve Internal Control levels, and thereby contribute to the enhancement of corporate ESG Performance.

2.3. The mediating role of External Supervision

Analysts are individuals (or groups) who use professional data to analyze the development of enterprises and industries. They focus on real events and data performance, and have deep insights into the development and business models of their respective fields. According to the Catering Effect, on the one hand, analyst groups will accommodate national policies and social hotspots for in-depth analysis. Therefore, companies with high digital levels and good social performance will receive priority attention[21]. On the other hand, according to reputation mechanism theory, since analysts' evaluations and reports have a certain degree of dissemination and influence in the market, companies will strive to perform well for the sake of reputation, in order to gain social recognition and trust, and thereby obtain more resources and opportunities. Negative evaluations by analysts may trigger negative market reactions, damage corporate reputation, and lead to consequences such as customer loss, strained partnerships, and declining market value. Shi Hujun et al. found that analyst attention

can significantly boost a company's ESG Performance, and this effect is noticeably stronger among non-state-owned enterprises[22]. Additionally, DT improves the quality of a company's external information disclosure, allowing analysts to gain a deeper understanding and evaluation of the company. This increases the attention from external stakeholders such as investors and governments, enabling the company to access a richer array of potential resources, thereby enhancing their capacity for non-economic operations and investments, which in turn contributes to the enhancement of corporate ESG Performance.[18].

Therefore, this paper proposes Hypothesis H3 in Figure1: Digital Transformation can increase analyst attention, enhance External Supervision, and thereby promote improvements in corporate ESG Performance.

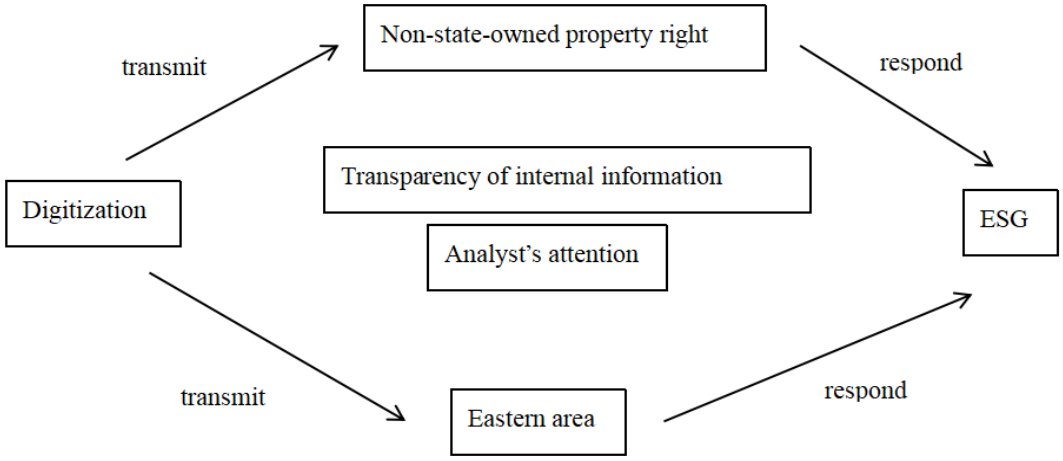

Figure 1. Logical relationship diagram

3. Model Design and Variable Description

3.1. Sample Selection and Data Sources

For this study, the sample consists of listed companies spanning from 2013 to 2023, which is screened according to the following criteria: (1) Exclude financial and insurance-related listed companies; (2) Exclude ST, *ST, and PT companies with poor operational performance; (3) Exclude companies lacking key variables. (4) Exclude samples with a debt-to-equity ratio greater than 1; (5) Trim continuous variables at the 1% and 99% percentiles. Data on corporate DT is sourced from annual reports of listed companies, data on ESG Performance is obtained from the Wind database, while all the other relevant data comes from the CSMAR database.

3.2. Model Design

To explore the relationship between DT and ESG Performance, a regression model (1) was established:

$$ESG_{i,t} = \beta_0 + \beta_1 DT_{i,t} + \beta_2 Controls_{i,t} + Year_t + Stkcd_i + \varepsilon_{i,t} \quad (1)$$

In Model (1), ESG is the dependent variable, representing environmental, social, and corporate governance factors; DT is the independent variable, representing Digital Transformation; Controls denotes control variables; Year and Stkcd are fixed effects, representing year fixed and firm fixed effects, respectively; ε is the random disturbance term; subscripts i and t denote individual firms and time, respectively.

To further explore the mechanism through which DT influences ESG, based on the suggestions for studying transmission mechanisms by Ning Shumei[19] and Dong Linlin[2], this paper constructs Model (2):

$$MV_{i,t} = \beta_0 + \beta_1 DT_{i,t} + \beta_2 Controls_{i,t} + Year_t + Stkcd_i + \varepsilon_{i,t} \quad (2)$$

In model (2), MV is the mediating variable, representing Analyst, which represents External Supervision, and Wg, which represents Internal Control levels.

3.3. Variable Settings

3.3.1 Dependent Variable

Following the approach of Li Fang et al., to quantify ESG performance, we adopt the ESG ratings provided by Huazheng as a proxy measure.[8]. Firms covered by Huazheng's ESG scheme are sorted into a nine-step ladder that runs from C up through AAA. Each notch on the scale is given a numeric code from 1 to 9 in ascending fashion, so the larger the figure, the stronger the implied ESG credentials.

3.3.2 Explanatory Variables

Digital Transformation Level (DT) draws on the Digital Transformation dictionary constructed by Wu Fei et al. to conduct word frequency statistics on digital keywords in company annual reports[23]. I gauge the intensity of a firm's DT by taking the natural log of one plus the overall count of relevant keywords.

3.3.3 Mediating Variables

This study uses External Supervision and Internal Control as mediating variables. External Supervision is proxied by analyst attention (Analyst), specifically the number of analysts tracking the company (number of teams). Internal Control is measured by corporate information transparency (Wg), based on the transparency ratings assigned by the Shenzhen Stock Exchange and Shanghai Stock Exchange. There are four levels: D, C, B, and A, with values ranging from 1 to 4 in ascending order.

3.3.4 Control variables

To more accurately explore the causal relationships among variables, this study references relevant research and selects the following control variables:

The leverage ratio (Lev) is expressed as total liabilities divided by total equity. Growth capability (Growth) is the revenue growth rate. Firm age (Age) is measured as the natural logarithm of the years elapsed since the firm went public. Big Four audit (Big4), where 1 indicates an audit by the Big Four and 0 otherwise. The dual-role dummy (Dual) equals 1 when the chair concurrently serves as CEO, and 0 otherwise. Board size (Board) is captured by the natural logarithm of the total count of directors on the board. The institutional ownership ratio (Ins) equals the percentage of outstanding shares held by institutional investors. Equity concentration (Top1) is measured by the percentage of total shares held by the largest shareholder. Detailed variable definitions are provided in Table 1.

Table 1 Indicator Explanation

Primary Indicator	Secondary Indicator	Tertiary indicators	References
Digital Transformation	Degree Of Digital Transformation (DT)	Add 1 to the total number of digital keywords and take the natural logarithm.	Wu Fei et al., 2021[23]
ESG	Environment、Society 、Governance (ESG)	Hua Zheng ESG Rating	Li Fang et al., 2025[8]
Internal Control	Internal Transparency (Wg)	Transparency rating scores for information disclosed by the Shenzhen Stock Exchange and Shanghai Stock Exchange	Ning Shumei and Cheng Zhengzhong, 2025[19]
External Supervision	Analysts' Focus (Analyst)	Number of analysts tracked in the CSMAR database (number of teams), taken as natural logarithm	Dong Linlin and Peng Ruohong, 2024[2]

4. Empirical Analysis

4.1. Descriptive Statistics

Descriptive statistics for all variables are reported in Table 2. The mean value of the dependent variable ESG is 4.075, with a standard deviation of 0.916, and maximum and minimum values of 6.000 and 1.250, respectively. This indicates that the overall ESG level of Chinese enterprises remains modest, and there are significant differences among enterprises. DT exhibits a mean of 1.539 and a standard deviation of 1.427, ranging from 0 to 5.159. This indicates that the degree of DT among different companies is generally low and there are significant differences between them.

Table 2 Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
DT	42035	1.539	1.427	0.000	5.159
ESG	42035	4.075	0.916	1.250	6.000
Analyst	25435	1.737	1.115	0.000	3.829
Wg	32655	3.026	0.653	1.000	4.000
Lev	42035	44.266	21.951	5.579	97.400
Growth	42035	15.142	44.759	-64.317	289.426
Age	42035	2.224	0.788	0.693	3.401
Big4	42035	0.069	0.254	0.000	1.000
Dual	42035	0.284	0.451	0.000	1.000
Board	42035	2.119	0.206	1.609	2.708
Ins	42035	43.433	24.556	0.310	91.828
Top1	42035	33.179	14.845	8.087	73.702

4.2. Basis Regression

To examine how corporate DT relates to ESG, this paper conducts regression analysis according to Model (1).

Table 3 sets out the regression results. In column (1) year- and firm-fixed effects are included, yet no additional controls are added. The DT coefficient equals 0.031 and is significant at the 0.1 % level. Column (2) of Table 3 adds the full set of controls while retaining year and industry fixed effects. It can be seen that the coefficient for DT is 0.036, which remains significant at the 0.1% level. Across both specifications—whether controls are omitted or included—the digitization measure exerts a robust, positive effect on ESG outcomes: firms that are further along in their digital transformation consistently display superior ESG ratings.

Table 3 Basis Regression

	(1)	(2)
	ESG	ESG
DT	0.031***	0.036***
	(4.270)	(4.960)
Growth		-0.001***
		(-3.860)
Lev		-0.006***
		(-11.240)
Age		-0.135***
		(-5.170)
Big4		0.176**
		(3.260)
Dual		-0.007
		(-0.410)
Board		0.053
		(1.050)
Ins		0.001
		(1.940)
Top1		0.003*
		(2.510)
_cons	4.024***	4.326***
	(358.200)	(33.450)
Year	Yes	Yes
Stkcd	Yes	Yes
N	41531	41531
R2	0.536	0.597
F	18.190	31.490

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

4.3. Endogeneity treatment and robustness test

4.3.1 Adjustment for control variables

The robustness of the findings can be markedly influenced by the choice of control variables. After removing the control variables of dual roles and Big 4 audits, the DT coefficient stayed significantly positive at the 0.1% level.

4.3.2 Instrumental variable method

A reverse causal link might exist: higher ESG could spur, rather than stem from, deeper DT. To mitigate possible endogeneity issues, the paper employs an instrumental-variable strategy when estimating DT's effect on ESG. Drawing on the research approach of Wang Yuncheng et al., we employ two-stage least squares to test for endogeneity and use the average DT level of companies by region-industry-year (IV) as the instrumental variable to conduct empirical analysis on Chinese listed companies[24]. On the one hand, in sectors where digitalization is already widespread, firms face stronger incentives to embrace new digital tools, thereby satisfying the relevance condition. On the other hand, investment decisions regarding DT are often independent across companies, thus meeting the exogeneity requirement for instrumental variables. The reported first-stage F-statistics comfortably exceed the threshold of 10, allowing to dismiss concerns over weak instrumental variable hypothesis. The stage-two regression results remain significantly positive, aligning with the baseline regression findings.

4.3.3 Lagged independent variable regression

The influence of a company's DT on ESG may exhibit a lag effect, meaning that the effects of DT on ESG levels require a response time. Therefore, this study analyzes the lagged independent variable. The lagged-DT coefficient stays significantly positive at the 1 % threshold, mirroring the baseline resultss.

4.4. Mechanism Analysis

4.4.1 External Supervision

Based on the Catering Effect, DT may improve a company's ESG Performance by increasing analyst attention. Column (1) in Table 4 reports that DT has a positive impact on analyst attention, with a coefficient of 0.033, which is significant at the 1% threshold. Column (2) reports the regression results on whether analyst attention mediates the relationship between DT and ESG Performance. The table shows that the coefficients for DT and analyst attention are 0.015 and 0.072, respectively, which are significant at the 5% and 1% levels. Furthermore, as shown in Column (5), the coefficient for DT is smaller than that for DT without considering analyst attention, indicating that analyst attention partially mediates DT's positive influence on ESG.

4.4.2 Internal Control

DT appears to enhance ESG by strengthening information transparency. Column (3) of Table 4 shows that the estimated coefficient of DT on information transparency is 0.012 and statistically significant at the 1% level, indicating that higher DT is associated with improved corporate transparency. In Column (4), the paper reports the regression results that examine whether information transparency serves as a mediating channel through which DT influences firms' ESG. As shown in the table, the coefficients for DT and information transparency are 0.018 and 0.153, respectively, both significant at the 1% level. Furthermore, as shown in Column (5), the DT coefficient shrinks once information transparency is accounted for, implying that part of DT's positive effect on ESG is transmitted through heightened transparency.

Table 4 Mediation effect

	(1)	(2)	(3)	(4)	(5)
	Analyst	ESG	Wg	ESG	ESG
DT	0.033***	0.015**	0.012***	0.018***	0.036***
	(4.515)	(2.519)	(2.738)	(3.411)	(4.960)
Analyst		0.072***		0.153***	
		(13.072)		(20.686)	
_cons	1.177***	4.266***	2.755***	3.823***	4.326***
	(9.309)	(42.214)	(39.959)	(43.513)	(33.450)
Year	Yes	Yes	Yes	Yes	Yes
Stkcd	Yes	Yes	Yes	Yes	Yes
N	25435	25435	32655	32655	41531
R^2	0.081	0.019	0.045	0.034	0.597
F	206.128	41.223	148.182	98.966	31.490

***p<0.01, **p<0.05, *p<0.10

4.5. Heterogeneity Analysis

4.5.1 Regional Heterogeneity

Following the regional classification by Liu et al., the 31 provinces were divided into two subsamples: the eastern region and the central-western region[25]. Column (1) and Column (2) in Table 5 show the regression results for the central-western region (East=0) and the eastern region (East=1), respectively. In central and western provinces, the DT–ESG link attains 5 % significance. However, for the eastern region, this impact is significant at the 0.1% level. Therefore, compared to the central and western regions, DT delivers a markedly stronger ESG uplift for firms in the eastern region.

4.5.2 Corporate Ownership Heterogeneity

The nature of corporate ownership is determined by the affiliation of the enterprise's primary investor. For enterprises with multiple economic components, such as joint ventures and shareholding cooperative enterprises, the primary investor may be ambiguous. Therefore, this study analyzes corporate ownership heterogeneity only for samples with clearly defined primary investors. Following Liu Jinhuan et al. [26], firms registered under codes 110, 141, or 151 are treated as state-owned enterprises (SOEs); all remaining registration types are designated non-state-owned.[26]. Columns (3) and (4) of Table 5 report the regression outcomes for non-state firms (SOE = 0) and state-owned enterprises (SOE = 1), respectively. Among non-state firms, the DT–ESG effect is significant at the 0.1 % level. However, for state-owned enterprises, this impact is only significant at the 5% level. Therefore, compared to state-owned enterprises, the positive influence of DT on ESG is markedly stronger in non-state-owned enterprises.

Table 5 Heterogeneity Analysis

	East=0	East=1	SOE=0	SOE=1
	ESG	ESG	ESG	ESG
DT	0.033*	0.034***	0.039***	0.027*
	(2.480)	(4.050)	(4.350)	(2.130)
_cons	3.907***	4.549***	4.179***	3.797***
	(15.880)	(29.170)	(25.980)	(14.640)
Year	Yes	Yes	Yes	Yes
Stkcd	Yes	Yes	Yes	Yes
N	12289	29229	24247	13689
R2	0.547	0.538	0.5432	0.578
F	8.333	22.040	24.997	4.266

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

5. Conclusions

5.1. Key Findings

Using regression models built with data from A-share listed companies between 2013 and 2023, I find that DT significantly enhances corporate ESG through internal information transparency and analyst attention. Heterogeneity analysis reveals that DT delivers a significantly larger ESG boost to non-state-owned firms and to companies located in eastern China.

5.2. Policy Implications

Firstly, government regulatory bodies should continue to refine systems related to DT. Also, tailor Digital Transformation policies to local conditions to differentiate efforts in enhancing corporate ESG Performance. Finally, strengthen supervision of internal information transparency, and encourage public participation in monitoring corporate transparency to reduce information asymmetry and mitigate corporate risks.

Secondly, enterprises should actively engage in Digital Transformation, fully recognizing and leveraging their inherent role. At the strategic level, digital strategies should guide direction by setting development objectives. At the technological application level, digital strategies should drive the adoption of technologies like artificial intelligence across the entire production and operation process, laying a solid foundation for enhancing ESG Performance.

Thirdly, stakeholders should fully consider a company's Digital Transformation progress when making decisions. Investors can then reference analyst coverage and internal information transparency to determine funding decisions. Consumers can similarly use this information to make purchasing choices. Investor and consumer responses can in turn encourage companies to improve their Digital Transformation, thereby enhancing ESG Performance and creating a virtuous cycle.

5.3. Research Limitations and Outlook

This study explores how corporate DT advances ESG responsibility performance, achieving certain theoretical and practical outcomes while retaining limitations. Firstly, the sample comprises Chinese A-share listed companies, excluding unlisted firms, resulting in limited coverage. Secondly, the study lacks sector-specific analysis, limiting the applicability of its findings. Furthermore, in the mechanism analysis section, the selected mechanism variables primarily rely on pragmatic logic and partial literature, lacking sufficient theoretical grounding. Consequently, future research should

expand the sample size, delve deeper into specific industries to derive more conclusions. Examining intrinsic connection requires ongoing dynamic observation.

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