



A Study on the Impact of Digital Technology Innovation on Corporate ESG Performance

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Abstract. This study employs a two-way fixed effects model to systematically examine the impact of digital technology innovation on corporate ESG performance, utilising a sample of Shanghai and Shenzhen A-share listed companies from 2017 to 2023. Robustness tests validate the reliability of the findings. Findings reveal that digital technological innovation significantly enhances corporate ESG performance by improving green innovation efficiency. This research provides theoretical underpinnings for companies advancing digital innovation and ESG practices, while also offering valuable insights for policy-makers seeking to foster synergistic development between digitalisation and green transformation.

Keywords: Digital technology innovation; ESG; Green innovation efficiency

1 Introduction

Driving the synergistic transformation towards digitalisation and greening is critical for businesses to align with national strategies and secure future competitiveness. Within this context, corporate ESG performance has transcended the realm of social responsibility metrics into a core indicator of long-term corporate value^[1]. However, the practical integration of ESG principles faces significant challenges, including high compliance costs and difficulties in quantifying non-financial outcomes. Digital technologies, such as AI and blockchain, present novel solutions to these impediments by enhancing data transparency and operational efficiency^[2]. Yet, extant literature on ESG drivers has predominantly focused on institutional and cultural ‘soft factors,’ offering limited insight into how technological ‘hard drivers’ fundamentally reshape ESG outcomes. Crucially, while some studies acknowledge digital innovation, they often treat it superficially—as a component of green innovation or a mere correlative factor—failing to unveil the intrinsic mechanisms through which technological capabilities interact with and reconfigure organizational structures to facilitate ESG performance. This leaves a critical “black box” in our understanding^[3]. This study aims to address this gap by proposing and empirically testing a core mechanism: green innovation efficiency. We posit that digital technology innovation enhances ESG perfor-

mance primarily by boosting the efficiency of transforming R&D inputs into tangible green outputs. Our findings confirm that this pathway is not merely incidental but central, revealing how technological empowerment translates into sustainable value.

The marginal contributions of this paper are threefold: First, it shifts the academic discourse from asking if digital technology matters to explaining how it matters, by pinpointing a specific and potent mediating mechanism. Second, it moves beyond treating technology as a black box, illustrating its role in optimizing the internal green innovation process. Finally, it provides actionable insights for managers and policy-makers seeking to leverage digital transformation for substantive ESG gains.

2 Theoretical Analysis and Research Hypotheses

2.1 The Impact of Digital Technology Innovation on Corporate ESG Performance

Digital technological innovation promotes corporate green innovation through information sharing and knowledge integration, thereby enhancing ESG performance. Enterprises leverage digital platforms to enhance internal and external communication and collaboration efficiency, facilitating partnerships with external institutions and integrating cross-sector resources to drive green innovation⁴. Concurrently, digital technologies assist enterprises in systematically consolidating fragmented knowledge and optimising green innovation technical resources, thereby improving energy and resource allocation efficiency and enhancing ESG environmental performance⁵. Corporate digital transformation not only directly drives technological upgrades in production processes but also significantly compensates for the costs incurred in ESG activities by substantially improving resource utilisation efficiency and effectively reducing reliance on high-energy-consumption resources⁶. The promotion and application of green innovation achievements have further accelerated the pace of corporate green transformation, thereby enhancing environmental performance, strengthening the fulfilment of social responsibilities, and ultimately elevating the overall ESG performance of enterprises.

H1: Digital technology innovation exerts a significant positive influence on corporate ESG performance.

2.2 The Mediating Role of Green Innovation Efficiency

Digital technologies drive corporate green transformation by enhancing the efficiency of green innovation, thereby improving ESG performance. Enterprises can utilise digital technologies to conduct in-depth analyses of big data patterns related to innovation, identifying superior innovation pathways and methodologies. This not only optimises innovation processes but also accelerates the exploration and development of core green technologies, significantly enhancing innovation efficiency and standards⁷. Moreover, digital technologies provide systematic platforms and tools for corporate R&D and innovation⁸, enhancing communication and collaboration efficiency in joint innovation. This drives structural transformation of innovation mechanisms,

fostering a continuous emergence of green innovation outcomes. The dissemination and application of green innovation outcomes further optimises resource allocation efficiency, reduces pollution emissions, and accelerates corporate green transformation. This, in turn, improves environmental performance, strengthens social responsibility fulfilment, and ultimately enhances the enterprise's overall ESG performance. Based on this, the following hypothesis is proposed:

H2: Corporate digital technology innovation enhances ESG performance by improving the efficiency of green innovation.

3 Research Design

3.1 Sample Selection and Data Sources

This study utilised Shanghai and Shenzhen A-share listed companies covered by Huazheng ESG ratings between 2017 and 2023 as the initial sample, applying the following screening criteria: (1) Exclusion of ST and *ST-classified enterprises; (2) Exclusion of listed companies in the financial sector; (3) Exclusion of samples with missing key variable data. To mitigate the impact of extreme values, all continuous variables underwent tail trimming (Winsorisation) at the 1% level. This yielded 13,012 valid observations. Corporate ESG data originated from Huazheng ESG Ratings, digital technology patent application data was sourced from the CNRDS platform, while other financial and control variables were drawn from the CSMAR database. Variable definitions are detailed in Table 1.

Table 1. Descriptive Statistics for Primary Variables.

Variable type	Variable code	Variable measurement	Mean	Std. Dev.	Min	Max
dependent variable	ESG	Huazheng ESG Rating	4.381	.897	2	6
Explanatory variable	DTIC	The natural logarithm of the number of independently filed digital economy patents in that year plus one	1.649	1.382	0	5.743
mediating variable	GIE	Ratio of Green Innovation Output to Innovation Input	.063	.064	0	.236
Control variables	Age	The natural logarithm of the number of years in the city	19.72	6.016	4	67
	Size	The natural logarithm of the number of employees	22.309	1.334	19.529	28.697
	TDR	Total liabilities/Total assets	.398	.191	.016	1.165
	ROA	Net profit/Total assets	.039	.074	-2.12	.759
	TOP1	Shareholding ratio of the largest shareholder	32.915	14.45	3.91	89.99

Growth	Revenue growth rate	.208	3.853	-1.445	429.03 6
Indep	Number of independent directors / Total number of directors	.38	.056	.143	.8
Board	Natural logarithm of board size	2.091	.196	1.386	2.89
Dual	Whether the chairperson and chief executive officer positions are combined: 1 if yes, 0 other- wise	.354	.478	0	1

3.2 Model Design

To examine the significant positive impact of corporate digital technology innovation on ESG performance, the following baseline model is constructed:

$$ESG_{i,t} = \alpha + \beta_1 DTIC_{i,t} + \beta_2 Controls_{i,t} + \varphi_i + \mu_t + \varepsilon_{i,t} \quad (1)$$

To test the mediating role of green innovation efficiency in the relationship between digital technology innovation capability and corporate ESG performance, the following mediation model is established based on the fixed-effects framework:

$$GIE_{i,t} = \alpha + \gamma_1 DTIC_{i,t} + \gamma_2 Controls_{i,t} + \varphi_i + \mu_t + \varepsilon_{i,t} \quad (2)$$

Furthermore, to present a comprehensive regression that includes both the independent variable and the mediator, the following full model is constructed:

$$ESG_{i,t} = \alpha + \theta_1 DTIC_{i,t} + \theta_2 GIE_{i,t} + \theta_3 Controls_{i,t} + \varphi_i + \mu_t + \varepsilon_{i,t} \quad (3)$$

Where i denotes the firm, t denotes the year, GIE represents green innovation efficiency, ESG denotes corporate ESG performance, and $Controls$ represents the set of control variables. The terms φ_i and μ_t denote firm-specific and time-specific fixed effects, respectively, and $\varepsilon_{i,t}$ is the idiosyncratic error term. Industry fixed effects are also controlled for where applicable to account for unobserved heterogeneity across sectors.

4 Analysis of Empirical Findings

4.1 Correlation Analysis

Table 2 reports the Pearson correlation coefficient matrix for all variables in this study. It can be observed that the digital transformation (DTIC) of enterprises in the sample exhibits a significant positive correlation with corporate ESG performance (ESG) at the 1% level (coefficient = 0.163). The mediating variable, information transparency, exhibits a negative correlation with ESG performance. Furthermore, while some control variables also demonstrate significant correlations, the correlation

coefficients are not large. Therefore, it can be concluded that multicollinearity is absent in the regression.

Table 2. Pearson correlation coefficient between variables.

Variable	1ESG	2DTIC	3GIE
1.ESG	1.000		
2.DTIC	0.163***	1.000	
3.GIE	0.105***	0.392***	1.000

Note: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Unless otherwise specified, the same applies to the table below.

4.2 Main Effect Test: The Impact of Corporate Digital Technology Innovation on ESG Performance

Table 3 presents the benchmark regression results. As shown in Column (1), without controlling for additional variables, the coefficient for the impact of corporate digital technological innovation on ESG performance is 0.1061, significant at the 1% level. Column (2) further incorporates control variables, yielding a coefficient of 0.0848, which remains statistically significant at the 1% level. Column (3) controls for both industry and year fixed effects, with the coefficient holding steady at 0.0774 and continuing to be statistically significant at the 1% level. These results collectively support the hypothesis that corporate digital technology innovation significantly enhances ESG performance, thereby validating Hypothesis H1.

Table 3. Main effects test.

	(1)ESG	(2)ESG	(3)ESG
DTIC	0.1061*** (11.7932)	0.0848*** (10.5570)	0.0774*** (9.5052)
AGE		-0.0010 (-0.5337)	-0.0016 (-0.8136)
SIZE		0.1844*** (16.1354)	0.1886*** (16.3198)
TDR		-0.9657*** (-13.0315)	-0.9598*** (-12.9760)
ROA		1.8329*** (9.3209)	1.9220*** (9.7524)
TOP1		-0.0001 (-0.1352)	0.0000 (0.0553)
GROWTH		-0.1815*** (-6.2866)	-0.1406*** (-4.7423)

INDEP		1.1225*** (4.3100)	1.1494*** (4.4299)
BOARD		0.0013 (0.0164)	0.0363 (0.4721)
DUAL		0.0681*** (3.0767)	0.0627*** (2.8253)
_cons	4.2065*** (219.4638)	0.0385 (0.1296)	-0.1928 (-0.6516)
year fe	No	No	Yes
Ind fe	No	No	Yes
N	13012	13012	13012
r2_a	0.0266	0.1190	0.1277

Note: All regression models in the table control for fixed effects for year and industry. The same applies below.

4.3 The Mediating Effect of Green Innovation Efficiency

To investigate the mechanism through which corporate digital technological innovation influences ESG performance, this study employs a two-step approach referencing Jiang Ting (2022) to examine mediating effects. The regression results are presented in Table 4. Column (1) of Table 4 indicates that the regression coefficient for corporate digital technology innovation is 0.077, warranting further examination of its underlying mechanism. Column (2) reveals that the coefficient for the effect of corporate digital technology innovation on green innovation efficiency is 0.016, with a significance level of 1%. This demonstrates that enhanced digital innovation capabilities foster improved green innovation efficiency, thereby further advancing ESG development. Hypothesis H2 is thus validated.

Table 4. Mediation effect test.

	(1)ESG	(2)GIE
DTIC	0.077*** (0.006)	0.016*** (0.000)
Other variables	Control	Control
N	13012.000	13012.000
r2_a	0.128	0.378

4.4 Robustness Tests and Endogeneity

(1) Replacement of explanatory variables. To comprehensively measure corporate innovation levels and enhance result reliability, this paper replaces the explanatory variable measurement with the ratio of corporate R&D expenditure to total assets

(DTIC1). Controlling for industry and year fixed effects, the test results in Column (2) of Table 5 show significance at the 1% level, consistent with prior conclusions. This indicates robust research findings.

(2) Substitution of the dependent variable. To mitigate potential bias arising from differing ESG performance measurement methodologies, this study re-ran the regression after altering the ESG performance metric, employing WIND's ESG (ESG1) rating data for estimation. As shown in Column (1) of Table 5, the results are significant at the 1% level, indicating robust regression outcomes. This confirms that the substituted dependent variable continues to support the preceding conclusions.

(3) One-period lag treatment. To examine the lagged effects of digital technology innovation on ESG performance, this study re-estimates the model after uniformly lagging both explanatory and control variables by one period, building upon the baseline regression. As shown in Column (3) of Table 5, the coefficient for lagged digital technology innovation (L.DTIC) remains significantly positive at the 1% level, consistent with prior findings. This confirms the robustness of our research conclusions.

Table 5. Robustness test results.

	(1)	(2)		(3)
	ESG1	ESG	One-phase lag	ESG
DTIC	0.395*** (0.027)		L.DTIC	0.078*** (11.94)
DTIC1		2.954*** (0.318)		
Other varia- bles	Control	Control	Other variables	Control
N	13012	13012	N	9149
r ² a	0.139	0.116	r ² a	0.151

5 Conclusions and Recommendations

This study demonstrates that corporate digital technology innovation significantly enhances ESG performance, not merely through a direct effect but primarily by elevating the efficiency of green innovation. This key finding, validated through rigorous endogeneity tests, illuminates the "black box" of the underlying mechanism: digital technology empowers firms to generate greater green patent outputs per unit of R&D investment. This heightened efficiency directly translates into superior environmental performance and, through improved reputation and governance, bolsters overall ESG outcomes.

The confirmation of this mediation effect carries profound implications. For corporate managers, it argues that digital technology should be strategically repositioned—from a tool for operational efficiency to a foundational asset for sustainable value creation. This necessitates deeper integration of digital strategies with ESG

goals, specifically by channeling technological capabilities into the green innovation process.

For policymakers, this research underscores the need to move beyond siloed initiatives. The focus should shift to crafting an integrated policy ecosystem that concurrently promotes digitalization and green transformation. Such an ecosystem, combining incentives for digital R&D in green sectors with support for ESG disclosure, can guide and accelerate the corporate transition towards a synergistic "digital-green" model.

In essence, translating the macro-level strategy of high-quality development into micro-level corporate practices requires a concerted effort. It is only through the dual drivers of proactive corporate strategy and a facilitatory government policy environment that the full potential of digital technology as a catalyst for sustainable development can be realized.

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