

An Analysis of the Impact of Digital Transformation on Corporate ESG Performance

Haoxu Fu^{1*}, Yuting Chen², Haomiao Li³

¹*Institute of Statistics and Mathematics, Zhongnan University of Economics and Law, Wuhan, China*

²*Institute of Finance, Zhongnan University of Economics and Law, Wuhan, China*

³*Institute of Business Administration, Zhongnan University of Economics and Law, Wuhan, China*

**Corresponding Author. Email: 3302109950@qq.com*

Abstract: This paper employs textual analysis and empirical data from the Wind Financial Terminal (CSMAR database) to investigate how digital transformation influences corporate ESG performance through the mediating roles of green innovation capability and total factor productivity. The findings reveal that digital transformation optimizes resource allocation and promotes green technological innovation, thereby enhancing environmental performance. At the same time, it improves production efficiency and resource utilization, strengthens corporate social responsibility fulfillment and governance capabilities, and significantly enhances overall ESG performance. This study provides a theoretical basis for corporate practices.

Keywords: Digital transformation, Green innovation capability, Total factor productivity, ESG performance, Corporate sustainability

1. Introduction

With the rise of the ESG framework, enterprises are increasingly integrating environmental, social, and governance (ESG) performance into their core strategies. This paper focuses on the critical issue of how digital transformation drives improvements in ESG performance through the dual mediating paths of green innovation capability and total factor productivity [1][2]. The goal is to uncover the intrinsic mechanisms through which digital technologies empower sustainable development. The core contribution of this study lies in constructing two theoretical linkages: “Digital Transformation – Green Innovation – ESG” and “Digital Transformation – Total Factor Productivity – ESG.” The paper argues that green innovation enhances environmental responsibility by optimizing resource management and product competitiveness, while improvements in total factor productivity provide the resource foundation for fulfilling social responsibilities and investing in governance. Ultimately, this research offers theoretically grounded and practically valuable strategies for aligning digital transformation with ESG objectives.

2. Theoretical analysis and research hypotheses

2.1. Digital transformation and corporate ESG performance

As the economy and society continue to evolve, enterprises are not only concerned with economic efficiency but are also placing greater emphasis on their environmental, social, and governance impacts. However, implementing ESG practices often involves high costs, long return periods, insufficient information disclosure, and limitations in resources and technology [3]. Digital transformation can address these challenges by enhancing information transparency and reducing transaction costs [4]. It also improves the efficiency of resource allocation and utilization and strengthens the effectiveness of corporate decision-making and operational management. Accordingly, this study proposes the following hypothesis:

H1: Digital transformation enhances corporate ESG performance.

2.2. Mechanisms through which digital transformation influences ESG performance

2.2.1. Digital transformation, green innovation capability, and ESG performance

Digital transformation breaks down information silos within firms and improves resource utilization efficiency, thereby enhancing environmental standards and the capacity for green technological innovation [5]. Green innovation, in turn, facilitates the development of green production models, the launch of environmentally friendly products, and the optimization of corporate governance structures, all of which contribute to improved ESG performance. Based on this, the study proposes:

H2: Digital transformation enhances corporate ESG performance by promoting green innovation capability.

2.2.2. Digital transformation, total factor productivity, and ESG performance

Automation and intelligent technologies enable real-time collection and analysis of production data, helping firms to forecast market demand, adjust production plans, and access diversified innovation tools, thus boosting total factor productivity [6]. An increase in total factor productivity enhances financial robustness and optimizes internal management processes, leading to improved ESG performance. Therefore, the study proposes:

H3: Digital transformation enhances corporate ESG performance by improving total factor productivity.

3. Research design

3.1. Sample selection and data sources

This study selects A-share listed companies on the Shanghai and Shenzhen stock exchanges from 2011 to 2023 as the research sample to empirically examine the relationship between digital transformation and corporate ESG performance. Samples from the financial sector, companies labeled ST and *ST, and those with missing data were excluded. Additionally, all continuous variables were winsorized at the 1st and 99th percentiles, resulting in 34,173 firm-year observations. Following the approach of Wu Fei et al. [7], this study employs a textual analysis method, extracting and logarithmically transforming the total number of keyword occurrences in annual reports to measure the degree of corporate digital transformation. ESG data were obtained from the Huazheng database, with ratings converted into numerical scores. Other firm-level data were sourced from the CSMAR database.

3.2. Variable definitions

3.2.1. Dependent variable: ESG performance

This study uses ESG rating data from the Huazheng database for the period 2011–2023. The database assigns ratings across nine levels: C, CC, CCC, B, BB, BBB, A, AA, and AAA. These ratings are converted into numerical scores from 1 to 9, with higher scores indicating better ESG performance.

3.2.2. Independent variable: digital transformation (dig)

Based on terms widely used in academic and industry contexts, a digital transformation keyword dictionary was constructed. Using Python, the annual reports of listed firms were analyzed to calculate keyword frequencies. The total frequency was then log-transformed to derive the independent variable (Dig), which reflects the extent of a firm's digital transformation.

3.2.3. Mediating variables: green innovation capability (GTI) and total factor productivity (TFP)

For green innovation capability, the study uses the 2010 IPC Green Inventory developed by the World Intellectual Property Organization (WIPO) to identify green patents. Following the methodology of Wang Pei and Chen Zhe et al. [8][9], patent applications were categorized into sectors such as alternative energy production, transportation, energy conservation, waste management, agriculture and forestry, regulatory design, and nuclear energy. Given the long application process of patents—which can already influence ESG performance during the application period—the number of green patent applications (rather than granted patents) is used, measured as $\ln(\text{number of green patent applications} + 1)$. The estimation of total factor productivity follows the approaches of Lu Xiaodong et al. [10] and Levinsohn et al. [11]. The Levinsohn-Petrin (LP) method is employed, where total output, capital, labor, and intermediate inputs are respectively proxied by operating revenue, net fixed assets, number of employees, and cash payments for goods and services from the CSMAR database.

3.2.4. Control variables

To ensure robustness, this study includes several control variables based on prior literature: return on equity (ROE), leverage (Lev), inventory ratio (INV), managerial ownership (Mshare), accounts receivable ratio (REC), Tobin's Q, controlling shareholder fund occupation (Occupy), return on assets (Roa), and cash flow ratio (Cashflow).

3.3. Model specification

To examine the relationship between digital transformation and corporate ESG performance, the following multiple linear regression models are constructed:

$$ESG_{it} = \alpha_0 + \alpha_1 Dig_{it} + \sum \alpha Control_{it} + \sum Year + \sum Ind + \varepsilon_{it} \quad (1)$$

$$Med_{it} = \beta_0 + \beta_1 Dig_{it} + \sum \beta Control_{it} + \sum Tear + \sum Ind + \varepsilon_{it} \quad (2)$$

$$ESG_{it} = \delta_0 + \delta_1 Med_{it} + \delta_2 Dig_{it} + \sum \delta Control_{it} + \sum Tear + \sum Ind + \varepsilon_{it} \quad (3)$$

Where: Model (1) estimates the direct effect of digital transformation on ESG performance; Models (2) and (3) test the mediating effects of green innovation capability (GTI) and total factor productivity (TFP), respectively; Med represents the mediators (GTI or TFP); i denotes the firm, ttt

denotes the year; Control represents the control variables; Year and IndIndInd denote year and industry fixed effects, respectively; ε is the error term.

4. Empirical analysis

4.1. Descriptive statistics

Table 1 presents the descriptive statistics for the main variables. The mean ESG score is 4.135 with a standard deviation of 0.918, indicating that the overall ESG performance of firms is relatively low, with substantial variation across companies. The wide range between the minimum and maximum values of Dig suggests that the sample covers a broad spectrum of digital transformation levels.

Table 1: Descriptive statistics of key variables

VarName	Obs	Mean	Median	SD	Min	Max
ESG	34173	4.135	4.000	0.918	1.000	8.000
DIG	34173	1.580	1.386	1.419	0.000	5.037
TFP	34173	8.368	8.265	1.066	4.403	13.106
GTI	34173	0.258	0.000	0.667	0.000	6.328
Lev	34173	0.421	0.412	0.203	0.035	0.925
ROE	34173	0.053	0.066	0.139	-0.962	0.414
Cashflow	34173	0.048	0.046	0.067	-0.199	0.266
INV	34173	0.138	0.110	0.124	0.000	0.778
TobinQ	34173	2.041	1.621	1.353	0.789	16.647
Mshare	34173	13.926	1.365	19.343	0.000	70.500
Occupy	34173	0.014	0.007	0.022	0.000	0.202

4.2. Baseline regression

Table 2 reports the baseline regression results. Column (1) shows the direct regression of the independent variable on the dependent variable. Columns (2) and (3) add fixed effects and control variables, respectively. Column (4) includes both industry and year fixed effects as well as all control variables. The results consistently show that digital transformation has a significantly positive effect on ESG performance, supporting Hypothesis H1.

Table 2: Baseline regression results

	(1) ESG	(2) ESG	(3) ESG	(4) ESG
DIG	0.102*** (29.76)	0.0308*** (4.99)	0.113*** (33.77)	0.0317*** (5.16)
_cons	3.973*** (544.78)	4.082*** (390.71)	4.147*** (227.75)	4.297*** (163.39)
Control	No	No	Yes	Yes
ind	No	Yes	No	Yes
year	No	Yes	No	Yes
N	34173	34173	34173	34173
Adj. R ²	0.025	0.419	0.093	0.426

Note: Robust standard errors are reported in parentheses. ***, * denote significance at the 1% and 10% levels, respectively. The same notation applies in the following tables.

4.3. Robustness checks

4.3.1. Replacing the dependent variable

To test the robustness of the findings, this study replaces the ESG rating data from the Huazheng database with ESG scores from Sino-Securities ESG (商道融绿). The regression results show that even after replacing the dependent variable, digital transformation still significantly enhances corporate ESG performance, providing further support for Hypothesis H1.

Table 3: Robustness test results

	Replacing the Dependent Variable	
	(1) ESG	(2) ESG
DIG	0.0161** (2.54)	0.0704*** (5.57)
_cons	4.358*** (125.23)	4.226*** (66.83)
Control	Yes	Yes
ind	No	Yes
year	No	Yes
N	12014	12014
Adjusted R ²	0.043	0.676

4.3.2. Endogeneity test

To address potential endogeneity caused by omitted variables, this study employs an instrumental variable (IV) approach. Two strategies are used to construct valid instruments: Lagged Variables: The first strategy uses the one-period and two-period lags of the explanatory variable (DIG) as instruments. Industry-Region Average: The second strategy uses the average level of digital transformation in the same industry and region. Since firms in the same industry and region tend to adopt similar digital practices, this average significantly influences an individual firm's digital transformation level, while being exogenous to its ESG performance, thereby satisfying the relevance and exclusion restrictions of instrumental variables.

Table 4 reports the IV regression results. In the first-stage regressions, the coefficients of the instruments are all significantly positive, and the F-statistics are well above the threshold of 10, confirming the strength and validity of the instruments. In the second-stage regressions, the coefficient of DIG remains significantly positive at the 1% level across all models, reaffirming the conclusion that digital transformation significantly improves ESG performance even after accounting for endogeneity. Thus, Hypothesis H1 is again supported.

Table 4: Endogeneity test results

	Lag 1		Lag 2		Industry Mean	
	(1) DIG	(2) ESG	(3) DIG	(4) ESG	(5) DIG	(6) ESG
DIG		0.0862*** (5.68)		0.129*** (2.74)		0.111*** (2.61)
IV	0.441*** (78.82)		0.154*** (23.58)		0.441*** (25.23)	

Table 4: (continued)

_cons	0.937*** (37.74)	4.199*** (113.61)	1.456*** (48.39)	4.111*** (48.36)	0.815*** (22.76)	4.178*** (60.91)
Control	Yes	Yes	Yes	Yes	Yes	Yes
ind	Yes	Yes	Yes	Yes	Yes	Yes
year	Yes	Yes	Yes	Yes	Yes	Yes
N	28414	28414	24223	24223	34173	34173
Adjusted R ²	0.836	0.439	0.808	0.447	0.790	0.426
F	788.352	35.331	80.537	22.979	89.812	48.097

5. Heterogeneity analysis and mechanism research

5.1. Heterogeneity analysis

The impact of digital transformation on ESG performance may vary depending on a firm's ownership type, size, and geographical location. This study conducts a heterogeneity analysis based on these three dimensions.

As shown in Table 5, with respect to ownership type, digital transformation significantly enhances ESG performance for both state-owned enterprises (Column (1)) and privately owned enterprises (Column (2)). In terms of firm size, digital transformation significantly improves ESG performance for large enterprises (Column (3)), while the effect is not statistically significant for small and medium-sized enterprises (Column (4)). Regarding geographical distribution, digital transformation significantly improves ESG performance in the central (Column (6)) and eastern (Column (7)) regions, whereas the effect is not evident for firms in the western region (Column (5)).

Table 5: Heterogeneity analysis results

	Ownership Heterogeneity		Firm Size Heterogeneity		Regional Heterogeneity		
	(1) ESG	(2) ESG	(3) ESG	(4) ESG	(5) ESG	(6) ESG	(7) ESG
DIG	0.0261** (2.43)	0.0371*** (4.96)	0.0543*** (5.81)	0.00283 (0.32)	0.00803 (0.42)	0.0459*** (2.98)	0.0331*** (4.62)
_cons	4.471*** (92.77)	4.209*** (132.66)	4.351*** (90.68)	4.210*** (121.42)	4.294*** (55.16)	4.164*** (62.02)	4.326*** (140.26)
Control	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ind	Yes	Yes	Yes	Yes	Yes	Yes	Yes
year	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	11843	22330	17087	17086	3838	5672	24663
Adjusted R ²	0.445	0.417	0.440	0.446	0.431	0.434	0.416

5.2. Mechanism research

Digital transformation can enhance firms' human capital, improve corporate governance, and strengthen information access, thereby promoting innovation. Green innovation capability (GIT) is a key mediating variable in the relationship between digital transformation and ESG performance. Empirical evidence suggests that digital transformation fosters green innovation, which helps reduce

pollution during production and improve environmental performance, ultimately boosting ESG outcomes.

As shown in Table 6, Columns (1) and (2) confirm that digital transformation has a significantly positive effect on green innovation capability, and in turn, green innovation capability significantly enhances ESG performance.

In addition, total factor productivity (TFP), an important indicator of a firm's resource efficiency, serves as another transmission channel. Digital transformation improves information transparency and TFP, which supports better ESG performance. It improves operational efficiency and perception capability, laying a foundation for ESG fulfillment. Research suggests that digital transformation indirectly influences ESG responsibility through innovation, information exchange, and financial performance. Higher TFP implies more efficient resource utilization, cost reduction, and improved sustainability, all of which enhance ESG outcomes.

Table 6, Columns (3) and (4), show that digital transformation significantly improves TFP, which in turn has a significantly positive effect on ESG performance.

Table 6: Mediating effect regression results

	(1) TFP	(2) ESG	(3) GIT	(4) ESG
DIG	0.0737*** (22.75)	0.0186*** (3.01)	0.0203*** (6.05)	0.0305*** (4.96)
TFP		0.176*** (16.02)		
GIT				0.0532*** (5.01)
_cons	7.736*** (554.44)	2.942*** (33.14)	0.197*** (13.62)	4.289*** (161.49)
Control	Yes	Yes	Yes	Yes
ind	Yes	Yes	Yes	Yes
year	Yes	Yes	Yes	Yes
N	34173	34173	34173	34173
Adjusted R ²	0.897	0.505	0.717	0.501

To further validate the robustness of the mediating effects, the Bootstrap method was applied with 5,000 resamples. The results confirm that green innovation capability and total factor productivity serve as partial mediators in the relationship between digital transformation and ESG performance. Hence, Hypotheses H2 and H3 are supported.

Table 7: Mediating effect of Green innovation capability

Effect Type	Coefficient	p-value	95% Confidence Interval
Indirect Effect	0.0130932	0.000	[0.0115855 , 0.0146009]
Direct Effect	0.1002154	0.000	[0.0935425 , 0.1068882]

Table 8: Mediating effect of total factor productivity

Effect Type	Coefficient	p-value	95% Confidence Interval
Indirect Effect	0.0301127	0.000	[0.0280116 , 0.0322138]
Direct Effect	0.0832116	0.000	[0.0766119 , 0.0898113]

6. Conclusion and implications

This study empirically examines the impact of digital transformation on corporate ESG performance. The main findings are as follows: First, digital transformation has a significant positive effect on ESG performance. Second, digital transformation improves ESG outcomes by enhancing green innovation capability and total factor productivity, both of which serve as partial mediating mechanisms. Third, heterogeneity analysis reveals that the positive impact of digital transformation on ESG performance is more pronounced in large enterprises and those located in the central and eastern regions of China.

Based on these findings, the following policy and managerial implications are proposed: Policy Recommendations: The government should work toward improving the policy framework that supports corporate digital transformation. Specifically, quantitative evaluation methods can be developed to assess the progress of digital transformation across enterprises. Additionally, a set of targeted incentive measures should be introduced to encourage both listed and non-listed companies to actively pursue digital transformation, thereby enhancing their motivation and capacity for ESG information disclosure. Corporate Strategy: Enterprises should fully recognize that improving digital transformation and ESG performance can help gain social recognition and attract capital investment. As ESG considerations increasingly influence investor decisions and corporate valuation, proactive digitalization and ESG enhancement are becoming critical to long-term competitiveness. Micro-Level Insights: At the firm level, businesses should seize the opportunities presented by digital transformation. By strengthening green innovation capabilities and improving production efficiency, firms can achieve more substantial improvements in ESG performance.

References

- [1] Du, C., & Li, Z. (2024). A study on the impact of digital transformation on corporate ESG performance. *East China Economic Management*, 38(7), 91–102. <https://doi.org/10.19629/j.cnki.34-1014/f.230921022>
- [2] Cheng, A. (2024). A study on the impact of corporate digital transformation on ESG. *Value Engineering*, 43(20), 26–29.
- [3] Zhang, Y., Zhai, J., Zhu, Y., et al. (2023). How does digital transformation affect corporate ESG performance? *Journal of China University of Geosciences (Social Sciences Edition)*, 23(6), 126–141. <https://doi.org/10.16493/j.cnki.42-1627/c.20231109.001>
- [4] Zhang, J. (2023). A study on the impact of digital transformation on corporate ESG performance: A dual perspective based on technological innovation and financing constraints. *Modern Finance*, (12), 11–19.
- [5] Hu, J., Han, Y., & Zhong, Y. (2023). How does corporate digital transformation affect ESG performance? Evidence from listed companies in China. *Industrial Economics Review*, (1), 105–123. <https://doi.org/10.19313/j.cnki.cn10-1223/f.20221104.001>
- [6] Han, Z., & Zhang, Y. (2023). Digital transformation and ESG performance: A mediating mechanism analysis based on information transparency and total factor productivity. *Modern Management Science*, (3), 141–150.
- [7] Wu, F., Hu, H., Lin, H., et al. (2021). Corporate digital transformation and capital market performance: Empirical evidence from stock liquidity. *Management World*, 37(7), 130–144.
- [8] Wang, P., Yang, S., & Huang, S. (2021). A study on the impact of environmental protection tax on corporate environmental, social, and governance (ESG) performance: The mediating effect of green technological innovation. *Taxation Research*, (11), 50–56.
- [9] Chen, Z., & Zheng, J. (2022). Can green technological innovation promote high-quality regional economic development? — Also on the selection effect of environmental policy. *Contemporary Economic Science*, (4), 43–58.
- [10] Lu, X., & Lian, Y. (2012). Estimating total factor productivity of Chinese industrial enterprises: 1999–2007. *Economic Research Journal (Quarterly)*, 11(2), 541–558.
- [11] Levinsohn, J., & Petrin, A. (2003). Estimating production functions using inputs to control for unobservables. *The Review of Economic Studies*, 70(2), 319–341.