

The impact of digital technology innovation on ESG performance: evidence from A-share listed companies in China

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Abstract. The notion of Environment, Social and Governance (ESG) underscores the necessity for businesses to prioritize non-financial aspects such as environmental preservation, social accountability, and corporate governance while striving for economic advantages. The implementation and utilization of digital technologies have greatly enhanced the ESG performance of firms. This study investigates the influence of corporate digital technology innovation on corporate environmental, social, and governance (ESG) performance. The analysis is based on a sample of A-share listed businesses throughout the period from 2013 to 2022. The results demonstrate that the rise in the level of corporate digital technology innovation has a notable beneficial effect on ESG performance, particularly among companies that are not heavily reliant on technology. Furthermore, this increase is more readily apparent. Furthermore, the two-step method confirms that the implementation of corporate digital technology innovation can enhance ESG performance through optimization of operational efficiency and minimization of agency costs. Furthermore, the enhancement of ESG performance also exerts a positive influence on company performance and helps to alleviate financing limitations. The results of this study offer fresh insights and pragmatic recommendations for organizations to enhance sustainability during the digital transformation process.

1 Introduction

Given the swift progress of the nation's economy, the paramount focus of modern civilization has become the achievement of a high standard of economic development. Every sector in society places significant emphasis on the notion of sustainable development and the implementation of ESG principles. ESG, or Environmental, Social, and Governance, refers to the commitment of organizations to consider not only economic gains but also non-financial aspects such as environmental protection, social responsibility, and corporate governance during investment and operation processes [1, 2]. One such notion is the ESG framework, which is a systematic approach to evaluate and direct a company's sustainable growth based on the three aspects of environment, society, and governance [3-5]. Furthermore, these elements not only influence the long-term viability of a business but also

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significantly shape its market perception and social standing [6]. In light of the increasing significance of global climate change and social equity concerns, investors, consumers, and regulators are increasingly expecting corporations to demonstrate superior performance in terms of environmental preservation, fulfillment of social obligation, and corporate governance framework [7]. Consequently, firms are placing more emphasis on integrating ESG principles into their strategy and managerial determinations to attain long-term value growth and efficient risk management [8]. The topic of enhancing a company's ESG performance has garnered significant interest from all sectors of society.

Against the backdrop of the rapid advancement of digital technology, the emergence and implementation of new-generation digital technologies such as cloud computing, artificial intelligence, and big data have greatly enhanced the practical capabilities of corporate environmental, social, and governance (ESG) practices and have become a crucial element in fostering its growth. Hence, in the context of enhancing corporate ESG performance, the indispensability of innovation and implementation of digital technology becomes evident.

2 Literature review

This study by Li et al. examined the mechanism of USB in enhancing company success using companies listed on the A-share main board of China's Shanghai and Shenzhen Stock Exchanges from 2010 to 2017 as research samples. The test findings derived from the internal mechanism indicate the presence of a mediating effect among them. Furthermore, the results clearly established that corporate ESG performance and its three dimensions have the potential to enhance corporate performance [9]. The study conducted by Hu et al. suggests that corporate digital transformation has the capacity to significantly improve company performance. Blockchain is the most widely recognized technology, and the digital transformation of established state-owned enterprises and non-high-tech enterprises has a particularly significant promotional impact. It is proven through economic analysis that enterprise digitalization can have beneficial economic impacts. Wu et al., investigated the correlation between enterprise digital transformation and capital market performance by analyzing empirical data on stock liquidity. The aim was to verify if digital transformation has provided firms with new growth momentum. The research findings indicate that there is potential to improve performance, stimulate company research and development and investment, reinforce asymmetric information asymmetry, and further amplify asymmetric information asymmetry through enterprise digital transformation [11]. Evidence from empirical research conducted by Wang et al. and other researchers using the MSCI index suggests that digital transformation has the potential to improve performance. Each 1% improvement in digital transformation results in a 0.096% boost in performance in terms of ESG responsibility [5]. The primary objective is to analyze the impact of corporate digital technology innovation on corporate ESG performance. Previous studies have mostly investigated the correlation between digital transformation and corporate ESG performance.

3 Methodology

This study utilizes a research sample of China's Shanghai and Shenzhen A-share listed companies from 2013 to 2022. It excludes ST, *ST, listed companies in the financial industry, and samples that were delisted midway during the sample period. The study also considers the presence of moderately high extreme values in individual variables, which have been reduced by 1% above and below. Corporate financial indicators and governance structure-related data in the study are sourced from the Guotaian Financial Database (CSMAR). Corporate ESG rating data is obtained from the Huazheng ESG Database. The digital

technology innovation patent indicator is derived from A in the China Research Data Service Platform (CNRDS). This study compares the patent classification numbers of listed firms with the digital technology patent classification numbers in the Key Digital Technology Patent Classification System [10]. The resulting data is then incorporated into the model following logarithmic processing. This paper establishes the following benchmark regression equation to examine the influence of corporate digital technology innovation on corporate ESG performance:

$$ESG_{it} = \alpha_0 + \beta_1 DPAT_{it} + \beta_2 CV_{it} + Industry_j + Year_t + \varepsilon_{it} \tag{1}$$

The ESG_{it} is the explained variable in this article, which represents the ESG performance of enterprise i in year t . The $DPAT_{it}$ is the core explanatory variable of this study, which represents the digital technology innovation level of enterprise i in year t . The CV_{it} are control variables, including financial indicators and governance indicators. The $Industry_j$ and $Year_t$ are industry fixed effects and year fixed effects respectively. The ε_{it} is the residual term.

4 Empirical results

4.1 Descriptive statistics

Table 1 presents the descriptive statistical findings for each variable. The ESG indicator has a mean value of 4.117, a standard deviation of 1.092, a low value of 1, and a maximum value of 8. The digital technology innovation index has a mean value of 1.626, a standard deviation of 2.495, a minimum value of 0, and a maximum value of 12.440. Evidence indicates that the sample organizations exhibit significant disparities in terms of their ESG performance and digital technology innovation.

Table 1. Descriptive Statistics.

Variable	Obs	Mean	Std.Dev.	Min	Max
ESG	30,150	4.117	1.092	1.000	8.000
creator	30,150	1.626	2.495	0.000	12.440
Size	30,150	22.290	1.334	15.580	28.640
Lev	30,150	0.422	0.203	0.008	0.998
Growth	30,150	0.144	0.321	-0.564	2.376
Top1	30,150	0.336	0.148	0.003	0.900
Board	30,150	2.113	0.199	1.099	2.890
Independent	30,150	0.378	0.056	0.143	0.800

4.2 Baseline regression

The results of the baseline regression estimation for this work are presented in Table 2. The univariate regression findings regarding the relationship between digital technology innovation and corporate ESG performance are presented in equation (1). The core variable coefficient, with a value of 0.096 and statistical significance at the 1% level, is observable. This article presents an initial demonstration of corporate digital technology innovation. The level rise will provide a certain degree of motivation to enhance the ESG performance of enterprises. The regression results are displayed in columns (2) and (3), respectively, with the inclusion of business financial and governance structure indicators. The CREAT coefficient remains statistically significant at the 1% level, providing further evidence that increasing the standard for corporate digital technology innovation has a substantial impact

on the performance of the business. The considerable promotion effect of ESG performance confirms the hypothesis of this study.

4.3 Robustness check

4.3.1 Replacing explanatory variables

The present study replaces the number of invention patents in the baseline regression as a metric for measuring enterprise digital technology innovation with the number of utility model patents. This substitution is included in the equation to assess the robustness of the finding, as illustrated in Table 3. The coefficient of the core variable remains statistically significant at the 1% level, suggesting that the results derived from the benchmark regression in this paper are strong and reliable.

Table 2. Baseline regression.

	(1)	(2)	(3)
VARIABLES	ESG	ESG	ESG
creator	0.096***	0.063***	0.062***
	(0.003)	(0.003)	(0.003)
Size		0.278***	0.262***
		(0.006)	(0.006)
Lev		-1.377***	-1.342***
		(0.035)	(0.035)
Growth		0.095***	0.099***
		(0.018)	(0.018)
Top1			0.490***
			(0.041)
Board			0.194***
			(0.038)
Independent			1.433***
			(0.126)
Constant	3.962***	-1.620***	-2.382***
	(0.008)	(0.118)	(0.145)
Observations	30,150	30,150	30,150
Industry	0.095	0.176	0.184
Year	Yes	Yes	Yes
F	Yes	Yes	Yes
r ² a	1171	1056	649.5

Note: Standard errors are in parentheses, ***, ** and * indicate significance at the 10%, 5% and 1% levels respectively, the same below.

Table 3. Robustness test-replacement of explanatory variables.

	(1)	(2)	(3)
VARIABLES	ESG	ESG	ESG
DPAT1	0.111***	0.075***	0.074***
	(0.004)	(0.004)	(0.004)
Constant	3.995***	-1.784***	-2.563***
	(0.007)	(0.117)	(0.144)
Observations	30,150	30,150	30,150
R-squared	0.087	0.174	0.181
Industry	Yes	Yes	Yes
Year	Yes	Yes	Yes
Financial Control	No	Yes	Yes
Governance Control	No	No	Yes
F	891.5	1032	635.8
r2 a	0.0846	0.171	0.179

4.3.2 Replace the explained variable

In addition, this paper also tests the robustness of the baseline regression conclusion by replacing the explained variables, as shown in Table 4. Since the benchmark regression uses Huazheng ESG rating data, this study uses Bloomberg ESG to replace it and re-expand the result estimation. Despite replacing the explained variables, the conclusion still shows that corporate digital technology innovation significantly promotes ESG performance.

Table 4. Robustness test-replacement of explained variables.

	(1)	(2)	(3)
VARIABLES	ESG	ESG	ESG
creator	0.664***	0.321***	0.315***
	(0.029)	(0.028)	(0.028)
Constant	29.865***	-31.000***	-33.673***
	(0.085)	(1.380)	(1.586)
Observations	10,081	10,081	10,081
R-squared	0.484	0.570	0.571
Industry	Yes	Yes	Yes
Year	Yes	Yes	Yes
Financial Control	Yes	Yes	Yes
Governance Control	512.9	655.5	378.8
F	0.480	0.567	0.567
r2 a	29.865***	-31.000***	-33.673***

4.3.3 Changing the sample interval

In light of the worldwide COVID-19 pandemic in 2020, this paper excluded samples subsequent to 2019 and recalculated the findings, resulting in the robustness test results presented in Table 5. The core variable remains statistically significant at the 1% level, confirming the reliability of the findings derived from the benchmark regression.

Table 5. Robustness test-excluding the impact of the new crown incident.

	(1)	(2)	(3)
VARIABLES	ESG	ESG	ESG
DPAT	0.089***	0.054***	0.053***
	(0.004)	(0.004)	(0.004)
Constant	3.968***	-1.817***	-2.674***
	(0.009)	(0.156)	(0.191)
Observations	18,554	18,554	18,554
R-squared	0.097	0.172	0.178
Industry	Yes	Yes	Yes
Year	Yes	Yes	Yes
Financial Control	No	Yes	Yes
Governance Control	No	No	Yes
F	510.9	553.3	339.3
r2 a	0.0935	0.168	0.174

4.4 Heterogeneity analysis

4.4.1 Heterogeneity analysis based on the nature of property rights

In order to estimate the regression results independently, this article conducts a separation of the sample into two groups: state-owned enterprises and non-state-owned enterprises. The reason for this is that firms with different property rights has different abilities to obtain resources. It produces the results stated in Table 6. The CREAT indicator demonstrates statistical significance at the 1% level in both the samples of state-owned and non-state-owned enterprises. Although all coefficient values for this variable are positive, the coefficient value for the non-state-owned enterprise sample is greater overall. The CREATXSOE coefficient, with a value of -0.019 and statistical significance at the 1% level, is shown in column (3) of the results. The aforementioned results indicate that both state-owned and non-state-owned enterprises can significantly profit from the influence of digital technology innovation on corporate environmental, social, and governance (ESG) performance. Non-state-owned enterprises tend to benefit more from this impact.

Table 6. Heterogeneity analysis of property rights.

	(1)	(2)	(3)
VARIABLES	state-owned enterprises	non-state-owned enterprises	Full sample
creator	0.050***	0.066***	0.068***
	(0.005)	(0.003)	(0.003)
CREATXSOE			-0.019***
Constant	-3.050***	-1.772***	-2.239***
	(0.224)	(0.206)	(0.149)
Observations	9,903	20,244	30,150
R-squared	0.274	0.154	0.185
Industry	Yes	Yes	Yes
Year	Yes	Yes	Yes
Control	Yes	Yes	Yes
F	287.3	342.5	512.4
r2 a	0.268	0.150	0.183

4.4.2 Heterogeneity analysis based on heavily polluting enterprises

The results of the heterogeneity study based on whether the enterprise's industry is severely polluting are displayed in Table 7. In both severely and non-heavily polluting enterprise samples, the CREAT index is significant at the 1% level, and the coefficient Although all the values are positive, the sample of highly polluting businesses has a greater coefficient value for this variable than the other samples. The CREATXPollute coefficient is 0.007, which is not significant, according to the values in column (3). The findings demonstrate that both heavily polluting and non-heavy polluting corporations benefit significantly from the influence of digital technology innovation on corporate ESG performance, but there is some degree of overlap in this promotion effect.

4.4.3 Heterogeneity analysis based on technology-intensive

According to the level of technological intensity of the organization, Table 8 presents the findings of the heterogeneity study. Both technology-intensive and non-technology-intensive enterprise samples clearly demonstrate that the CREAT index is statistically significant at the 1% level, with consistently identical coefficient values. Despite its positive nature, the coefficient value for this variable is higher in the sample of severely polluting enterprises compared to the whole sample. The coefficient for CREATXTech, as shown in column (3), is -0.018, thereby demonstrating statistical significance at the 1% level. The above-described results indicate that digital technology innovation has a significant promotion effect on corporate ESG performance in both technology-intensive and non-technology-intensive firms. In the latter instance, this promotion effect is more prominent.

Table 7. Heterogeneity analysis-heavy polluting enterprises.

	(1)	(2)	(3)
VARIABLES	Heavy polluting enterprises	Non-heavy polluting enterprises	Full sample
creator	0.075*** (0.008)	0.059*** (0.003)	0.061*** (0.003)
CREATXPollute			0.007
Constant	-2.332*** (0.326)	-2.380*** (0.162)	-2.371*** (0.145)
Observations	6,649	23,501	30,150
R-squared	0.153	0.198	0.184
Industry	Yes	Yes	Yes
Year	Yes	Yes	Yes
Control	Yes	Yes	Yes
F	138.9	518.0	568.4
r ² a	0.150	0.195	0.181

5 Further analysis

5.1 Mechanism inspection

Furthermore, apart from the aforementioned direct impact link, this essay takes into account the method by which digital technology innovation affects corporate ESG. The present study will draw upon Jiang Ting's two-step approach. Firstly, statistical findings will be used to establish the substantial impact of the explanatory variable on both the mediating and

explained variables. Secondly, a literature review will be conducted to illustrate the significant influence relationship between the mediating variable and the explained variable. This will thus provide evidence for the presence of a transmission mechanism. The precise estimation results are shown in Table 9. is defined as the influence of cutting-edge digital technology on the efficiency of business operations, measured by the operational profit margin; (2) is defined as the effect of digital technology innovation on the costs incurred by corporate agencies, measured by the capital turnover rate. The CREAT coefficients exhibit statistically significant positive values at the 1% level. This implies that the innovation of corporate digital technology can greatly enhance corporate operating profit margins and capital turnover rates. Consequently, this can lead to improved economic efficiency and a reduction in agency costs. Enhancement of business operational efficiency and minimization of agency costs can enable firms to generate additional capital income for the purpose of advancing their own ESG initiatives.

5.2 Analysis of economic results

This study includes an analysis of the economic impacts of ESG, as well as performance indicators and limitations on business financing. The precise estimation findings are shown in Table 10. Evidently, the ESG coefficients are 0.010 and 0.008, correspondingly, and both exhibit statistical significance at the 1% level. This indicates that improving a company's environmental, social, and governance (ESG) performance has a beneficial impact on its financial limitations and overall performance.

Table 8. Heterogeneity Analysis-Technology Intensive.

	(1)	(2)	(3)
VARIABLES	Technology-intensive enterprises	Non-technology-intensive enterprises	Full sample
creator	0.056***	0.076***	0.074***
	(0.003)	(0.005)	(0.005)
CREATXTech			-0.018***
			(0.006)
Constant	-2.082***	-2.539***	-2.354***
	(0.221)	(0.194)	(0.145)
Observations	14,214	15,936	30,150
R-squared	0.148	0.218	0.184
Industry	Yes	Yes	Yes
Year	Yes	Yes	Yes
Control	Yes	Yes	Yes
F	285.1	368.1	569.7
r2_a	0.147	0.214	0.181

Table 9. Mediation effect test.

	(1)	(2)
VARIABLES	ROS	THEM
creator	0.002***	0.006***
	(0.000)	(0.001)
Constant	-0.396***	0.479***
	(0.019)	(0.067)
Observations	29,548	29,548
R-squared	0.276	0.275
Industry	Yes	Yes
Year	Yes	Yes
Control	Yes	Yes
F	1267	203.2
r ² a	0.274	0.273

Table 10. Economic Results Analysis.

	(1)	(2)
VARIABLES	LONG	on
ESG	0.008***	0.010***
	(0.000)	(0.001)
creator	0.002***	0.009***
	(0.000)	(0.001)
Constant	-0.174***	-4.359***
	(0.009)	(0.035)
Observations	30,150	30,134
R-squared	0.281	0.193
Industry	Yes	Yes
Year	Yes	Yes
Control	Yes	Yes
F	1268	195.8
r ² a	0.279	0.191

6 Conclusion

Through research and analysis, it is found that the degree of corporate data technology innovation has a significant promotion effect on corporate ESG performance, especially for non-technology-intensive companies. On the other hand, through the two-step method, it was found that the degree of innovation of corporate digital technology can affect corporate operating profit margins and capital turnover rates. At the same time, the improvement of ESG performance also has a good promotion effect on corporate performance.

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