Corporate Digital Transformation and ESG Performance - Evidence from Chinese-Listed Companies

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Abstract. Corporate digital transformation provides the endogenous motivation to stimulate corporate ESG performance by helping companies to optimize innovation resource allocation and reduce financing costs. This paper empirically examines the impact and mechanism of corporate digital transformation on corporate ESG performance using Shanghai, and Shenzhen A-share listed companies from 2011-2021 as the research sample. It is found that digital transformation significantly enhances the ESG performance of enterprises, among which the performance of artificial intelligence is more prominent. This finding still holds after a series of robustness tests and endogeneity treatments. Taking the social spillover effects of digital transformation as the starting point, this paper provides empirical evidence and research insights to broaden the development path of Chinese enterprises to improve ESG performance and implement the "double carbon" goal.

Keywords: corporate digitalization; ESG; green innovation; financing constraints.

1. Introduction

The concept of ESG (Environmental, Social, Governance) was first introduced by the United Nations Global Compact in 2004, emphasizing integrating environmental, social, and governance-related issues into relevant investment research and corporate evaluation criteria. The ESG concept puts forward requirements for enterprises to fulfill environmental responsibility and achieve green development and is a further concretization and extension of corporate social responsibility (CSR) (Gillan et al., 2021). Some literature has pointed out that ESG disclosure is beneficial to reduce company costs and to improve company value and performance in both the short and long term (Wang et al., 2022). Corporate ESG reduces the cost of capital for production and operations and minimizes information asymmetry between managers and external capital providers, making it easier for innovative firms to raise capital and build good relationships with important stakeholders (including employees, customers, and activist organizations), leading to a better reputation (Broadstock et al., 2021).

With the deep evolution of the new technological revolution, the Chinese government attaches great importance to the digital economy. The 2021 Government Work Report points out the need to accelerate digital development and collaboratively promote digital industrialization and digital transformation of industries. The deep integration of the Internet, big data, artificial intelligence, and the real economy has driven the digital transformation of economic activities to accelerate, and data has become a new factor of production in addition to land, capital, and labor (Xie et al., 2020). Existing studies have been conducted on enterprise growth. Existing studies have pointed out that digital transformation can promote enterprise growth by improving labor efficiency, reducing operating costs, and enhancing internal control (Ni, K. J., and Liu, X. Y., 2021). By facilitating firms to establish connections with other innovation agents and aggregating innovation resources, digital transformation is important in driving firms to integrate innovation (Shuhan Zhang and Xiaoxiang Li, 2022). Inside and outside the enterprise, digital technologies can enhance the speed of information flow in the enterprise, and digital transformation of enterprises has been shown to have positive effects on the supply of business credit to customers (Qi, Huaijin et al., 2023), analyst forecast accuracy (Wang, Yao et al., 2023), and auditor selection (Liu, Bin and Wang, Chuanlin, 2023).

The literature on the relationship between corporate digital transformation and ESG performance currently needs to be more directly relevant. Hu Jie (2022) takes Shanghai and Shenzhen A-share listed companies as an example and points out that corporate digital transformation can significantly

improve corporate ESG performance, with blockchain technology performing more prominently. Wang, Navy et al. (2022) found that a 1% increase in the degree of digital transformation was associated with a 0.096% increase in corporate ESG performance based on MSCI indices.

The possible marginal contributions of this paper are mainly reflected in the following points. First, it attempts to explore the social spillover effects of digital transformation from the perspective of corporate ESG performance by including corporate digital transformation and corporate ESG performance in the same analytical framework, which broadens the existing studies in corporate ESG-related literature. Second, this paper provides empirical evidence on the enhancing effect of digital transformation on corporate ESG performance and its mechanism and heterogeneity by using a sample of A-share listed companies in Shanghai and Shenzhen from 2011-2021, which helps enterprises to adopt differentiated and dynamic strategies in digital transformation practices and balance economic and social benefits. Thirdly, this paper reveals that accelerating green innovation and alleviating financing constraints are the mechanisms of corporate digital transformation to boost corporate ESG performance.

2. Theoretical mechanisms and research hypotheses

As China accelerates its high-quality economic development and digital economy, the digital transformation of enterprises profoundly changes their production methods, organizational forms, marketing models, management models, and business strategies (Chen-Yu Zhao, 2022) . Further, improved information transparency between firms and their stakeholders helps to curb the tendency of internal opportunism, which has a driving effect on CSR performance (Xiao, Hongjun et al., 2021), which will drive firms to pay attention to environmental changes, social events, and sustainability capabilities, thereby improving ESG performance. Second, based on principal-agent theory, from an internal perspective, digital transformation can promote corporate growth, improve corporate governance by using operational information data, strengthen supervision and incentives for management, and improve internal control and supervision(Xie Weimin et al., 2022). In addition, by optimizing resource allocation, digitalization can improve the investment of human and financial resources in innovation and achieve "quality and quantity" of green innovation (Xiao, Jing, and Zeng, Ping, 2022), and promote the strategic thinking that economic benefits and social and environmental values are win-win for enterprises, thus promoting ESG development. To this end, hypothesis 1 is proposed.

Hypothesis: Enterprise digital transformation improves ESG performance.

3. Research design

3.1 Sample selection

Drawing on the methods of Hu Jie et al. (2022) and Xie Hongjun et al. This ESG has the characteristics of high update frequency (quarterly update), wide coverage (covering all A-share listed companies), and high data availability (Linlin Wang et al., 2022). The CSI ESG index system is based on the index scores, and the final nine grades of C~AAA ratings are obtained. To facilitate the empirical analysis, the C~AAA ratings are assigned 1~9, respectively. 2.

Based on this, this paper uses the text analysis method based on Wu, Fei et al.'s (2022) study and uses text mining technology to measure the number of keywords related to "digitalization" in the annual reports of Chinese listed companies or their frequency of occurrence to measure the level of digital transformation of enterprises.

Digital transformation is a major strategy for the high-quality development of enterprises, which is more likely to be reflected in enterprises' summarized and guiding annual reports. The vocabulary used in the annual report reflects the enterprise's strategy and reflects the enterprise's business philosophy and development path. Referring to Wu Fei et al. (2022), this paper measures the degree of digital transformation of enterprises through the word frequency statistics of listed companies'

annual reports about their digital transformation. The specific processing methods are as follows: first, this paper uses Python crawler function to obtain and organize all the annual reports of A-share listed companies in SSE and SZSE, and then extracts all the text contents through Java PDFbox library. Secondly, based on the characteristic words of "underlying technology application" (including artificial intelligence technology, big data technology, cloud computing technology and blockchain technology) and "technology practice application" (including digital technology application), the annual reports of listed companies are extracted The high-frequency words related to the digital transformation of enterprises are extracted from the annual reports of listed companies. Finally, the Jieba function is used to split the words of all samples and form a data pool, and the collected feature word spectrum is searched, matched, and counted to form a summed word spectrum. The natural logarithm of the summed word spectrum plus 1 is taken as the indicator of digital transformation of listed companies, which is expressed by digit. The larger the Digit value is, the higher the degree of digital transformation of entity enterprises.

3.2 Methodology

$$ESG_{it} = \alpha_0 + \alpha_1 digt_{it} + \alpha_2 Z_{it} + \mu_i + \delta_t + \varepsilon_{it} \quad (1)$$

where ESG_{it} is the ESG performance score of firm i in period t, and $digt_{it}$ is the degree of digital transformation of firm i in period t. In order to address the endogeneity problem interference caused by omitted variables, this paper introduces the following control variables (Zit) regarding existing literature (Wang, Navy et al., 2022; Hu, Jie et al., 2022). Specifically, firm size (size), measured as the logarithm of the firm's total assets; firm age (age), measured as the logarithm of the firm's years of establishment; firm growth capacity (growth), measured as the growth rate of the firm's total assets; firm duality rate (dual), measured as the concurrent appointment of the firm's chairman and general manager; board size (board), measured as the logarithm of the firm's The board size is measured by the logarithm of the number of board members, and the equity concentration (top10) is measured by the shareholding ratio of top 10 shareholders. At the same time, the model is designed to avoid individual heterogeneity in the within-group regressions, thus adding individual fixed effects indicating that city i does not change over time, and then indicating time fixed effects. Further, the random error terms in this paper are clustered to the city level to address the systematic heteroskedasticity of the model.

3.3 Data

In this paper, we select listed companies in Shanghai and Shenzhen A-shares from 2011-2021 as the research object and screen them according to the following steps: (1) exclude financial listed companies; (2) exclude samples with missing financial data or insolvency; (3) exclude samples that are marked ST or *ST in the year. Firm-level cluster regressions are performed on the samples to eliminate the interference of differences between data groups and reasonably control heteroskedasticity's effect. The financial data used in the study were derived from the CSMAR database.

4. Empirical Analysis

4.1 Benchmark regression

Table 1 shows the results of the benchmark regressions in this paper. Column (1) of Table 1 includes only the core explanatory variables of enterprise digital transformation. The results show that enterprise digital transformation positively contributes to enterprise ESG performance at the 1% significance level. Columns (2) to (5) of Table 1 show the regression results after adding the control variables of firm size, age, and growth capability. The results indicate that corporate digital transformation still positively contributes to corporate ESG performance at the 1% significance level.

The regression results in column (6) show that every 1% increase in the degree of digital transformation of enterprises will positively contribute to a 0.046% increase in ESG performance. The above results indicate that corporate digital transformation can effectively contribute to promoting corporate ESG practices, which in turn improves corporate ESG performance, thus validating hypothesis 1.

In addition, the regression results of the control variables are in line with expectations. Taking column (6) as an example, enterprise size and enterprise growth capability positively promote enterprise ESG performance at 1% and 5% significance levels, respectively, while enterprise age suppresses enterprise ESG performance at 5% significance level, indicating that larger developing enterprises may be more sensitive to the development of digital technology, and better growth capability can help them adapt more quickly to the external business activities and internal The scale and strength of these companies will support their ESG practices and improve their ESG performance; the rate of combining two positions in a company positively promotes ESG performance at the 10% significance level, indicating that the combination of two positions of chairman and general manager may enhance the autonomy and risk-taking ability of the general manager in ESG practices, which is more conducive to The size of the board of directors inhibits ESG performance at 1% significance level, suggesting that a large board of directors may be more difficult to coordinate and unify their opinions than a small board of directors, which leads to inefficient governance and is not conducive to ESG decision making and implementation in the digital transformation. This indicates that a more concentrated shareholding of major shareholders implies higher control, and the interests of major shareholders are more aligned with those of the company, which makes the governance and supervision of the company more efficient and easier to make ESG enhancement decisions that are beneficial to the long-term development of the company.

Table 1. Baseline regression

	(1)	(2)	(3)	(4)	(5)	(6)
digt	0.087***	0.048***	0.048***	0.048***	0.049***	0.046***
	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)
size		0.211***	0.224***	0.175***	0.179***	0.157***
		(0.019)	(0.019)	(0.021)	(0.021)	(0.022)
age			-0.201***	-0.221***	-0.222***	-0.112**
			(0.037)	(0.039)	(0.039)	(0.044)
growth				0.234**	0.234**	0.229**
				(0.101)	(0.101)	(0.095)
dual				0.003**	0.003**	0.003*
				(0.002)	(0.002)	(0.002)
board					-0.156***	-0.167***
					(0.039)	(0.039)
top10						0.006***
						(0.001)
_cons	6.233***	1.651***	1.823***	2.957***	3.244***	3.148***
	(0.030)	(0.410)	(0.412)	(0.457)	(0.463)	(0.463)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
N	32891	32786	32786	26360	26360	26360
adj. R^2	0.582	0.588	0.589	0.600	0.600	0.601

Note: ***, **, * denote significant at the 1%, 5% and 10% levels, respectively, with robust standard errors in parentheses (same as in the table below)

4.2 Robustness analysis

4.2.1 Substitution of explanatory variables

In the baseline regression part, this paper uses the total indicators of enterprise digital transformation for the regression. In the robustness test, the

Wu et al. (2022) and Hu et al. (2022), the five digital lexicons of "artificial intelligence", "blockchain", "cloud computing", "big data" and "digital application" are replaced respectively. "and "digital application" were replaced with the core explanatory variables. The test results are shown in Table 2. The results show that all five digital dictionaries positively contribute to corporate ESG performance at 1% significance level, and the baseline regression results are robust. Among them, the digital application has the largest impact coefficient on corporate ESG performance, and every 1% increase in digital application level will promote corporate ESG performance by 0.021%; artificial intelligence is the second, and every 1% increase in artificial intelligence level will improve corporate ESG performance by 0.019%. The main reason is that China still needs a unified and effective ESG information disclosure and evaluation system at this stage. It is difficult for enterprises to quantify and data their ESG practice goals, which will affect the effect of corporate ESG performance. The application of digital technology is expected to digitize ESG practices and management processes, help companies use digital tools to pinpoint stakeholder needs (Xiao Hongjun and Shang Huichen, 2022), quantify ESG performance and practices, and improve corporate ESG performance more effectively. Moreover, artificial intelligence uses its learning, natural language generation, and computer vision technologies to realize the intelligent operation of entities, which can technically empower enterprise supply chain reconstruction from three dimensions: platform reconstruction, ecological reshaping, and advantage reconstruction (Chen, J. Xiao, 2023), thus effectively reducing the operating costs of enterprises, optimizing the allocation of enterprise resources, and laying a good material foundation for enterprises to carry out ESG practices. Therefore, the positive contribution of digital applications and artificial intelligence to corporate ESG performance is more obvious.

Table 2. Robustness test I

	Artificial Intelligence	Artificial Intelligence	Cloud Computing	Big Data	Digital Applications
	(1)	(2)	(3)	(4)	(5)
digt11	0.073***				
	(0.021)				
digt12		0.013***			
		(0.004)			
digt13			0.038***		
			(0.011)		
digt14				0.051***	
				(0.015)	
digt15					0.081***
					(0.023)
size	0.157***	0.157***	0.157***	0.157***	0.157***
	(0.022)	(0.022)	(0.022)	(0.022)	(0.022)
age	-0.112**	-0.112**	-0.112**	-0.112**	-0.112**
	(0.044)	(0.044)	(0.044)	(0.044)	(0.044)
growth	0.229**	0.229**	0.229**	0.229**	0.229**
	(0.095)	(0.095)	(0.095)	(0.095)	(0.095)
dual	0.003*	0.003*	0.003*	0.003*	0.003*
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
board	-0.167***	-0.167***	-0.167***	-0.167***	-0.167***
	(0.039)	(0.039)	(0.039)	(0.039)	(0.039)
top10	0.006***	0.006***	0.006***	0.006***	0.006***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
_cons	3.148***	3.148***	3.148***	3.148***	3.148***
	(0.463)	(0.463)	(0.463)	(0.463)	(0.463)
Firm FE	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes
N	26360	26360	26360	26360	26360
adj. R^2	0.601	0.601	0.601	0.601	0.601

4.2.2 Substitution of explanatory variables

In the baseline regression, we use the Huawei data, so we use Bloomberg data again in the robustness test section. Bloomberg data scoring system is more reliable because its scores are more correlated with those of other institutions; Bloomberg ESG data evaluation system is scientifically comprehensive and widely sourced, and its sources include corporate responsibility reports, annual reports, ESG reports, and Bloomberg's surveys; Bloomberg institution's ESG scoring system covers a large sample size of domestic listed companies with a long year. For example, 1,193 Chinese listed companies received MCSI ESG scores in 2020, about half of the number of Bloomberg's rating system. Therefore, this paper selects the Bloomberg ESG score index to measure the ESG performance of enterprises concerning the study of Nie Huihua (2022). The ESG disclosure index from Bloomberg Consulting varies within the numerical range of [0, 100]. The higher the score of this variable, the higher the degree of ESG disclosure of the response listed companies, i.e., the better the ESG performance of enterprises.

In addition, this paper further verifies the impact of digital transformation on each of the three dimensions (Environmental, Social, and Governance) of corporate ESG performance based on the benchmark regression, and the regression results are shown in columns (3) (4) (5) of Table 3. The results indicate that digital transformation has a significant positive contribution to all three dimensions of corporate ESG performance, with a more prominent positive contribution to corporate governance, where every 1% increase in the degree of digital transformation of a company will contribute to a 0.013% increase in the level of corporate governance.

Table 3. Robustness test II

	ESG		*Environmental*	*Social*	*Governance*	*Iv_post*	
	(1)	(2)	(3)	(4)	(5)	(4)	(5)
digt	0.015***	0.012***	0.010***	0.012***	0.013***		0.526***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)		(0.000)
Iv_post						0.305***	
						(0.000)	
size		0.023***	0.020***	0.024***	0.026***	0.267***	-0.069***
		(0.005)	(0.005)	(0.005)	(0.006)	(0.000)	(0.000)
age		0.012	0.011	0.013	0.014	0.594***	-0.023
		(0.014)	(0.012)	(0.014)	(0.015)	(0.000)	(0.469)
growth		0.020	0.018	0.021	0.023	0.223***	-0.095***
		(0.015)	(0.013)	(0.015)	(0.017)	(0.000)	(0.002)
dual		0.000	0.000	0.000	0.000	0.001	-0.000
		(0.000)	(0.000)	(0.000)	(0.000)	(0.434)	(0.500)
board		-0.001	-0.001	-0.001	-0.002	0.019	-0.025
		(0.008)	(0.007)	(0.008)	(0.009)	(0.174)	(0.170)
top10		0.000*	0.000*	0.001*	0.001*	0.004***	-0.001
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.264)
_cons	2.605***	2.011***	1.749***	2.054***	2.223***		
	(0.007)	(0.117)	(0.102)	(0.120)	(0.130)		
Anderson LM							208.319***
Wald F							213.425***
F						213.430	
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	11660	10249	10249	10249	10249		9684
adj. R^2	0.813	0.820	0.820	0.820	0.820		0.601

5. Conclusion and Insight

Under the wave of the new technological revolution, it has become an increasingly important strategic tool for enterprises to accelerate digital development, promote digital transformation of economic activities, and accelerate digital technology to empower traditional industries. This paper selects Shanghai and Shenzhen A-share listed companies from 2011-2021 as research samples and empirically examines the effect and mechanism of the impact of corporate digital transformation on the corporate ESG performance of listed companies in the context of booming digital economy. The results of the empirical study show that digital transformation can significantly improve corporate ESG performance, and this conclusion still holds after a series of robustness tests.Based on the above research findings, this paper makes the following recommendations.

First, at the enterprise strategy level, enterprises should focus on high-quality development of the digital economy, empower traditional industries through digital, and promote the effective combination of the digital economy and the real economy.

Second, at the level of corporate governance, enterprises should seize the transformation opportunity and actively adapt to digital governance as digital technology promotes digital transformation of economic activities. A more transparent internal information network and database will also provide investors and external markets with a convenient way to monitor companies and reduce information asymmetry, thus alleviating the problem of financing constraints and supporting companies to improve their ESG performance.

Third, at the government policy level, it should attach great importance to digital development, continue to optimize industrial transformation and innovation development policies that encourage digital transformation of enterprises, and pay full attention to ESG concepts and actively promote ESG practices.

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