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Enterprise Digital Transformation and ESG Performance

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Abstract

In recent years, the comprehensive performance of enterprises in the environment, society and corporate governance (ESG) has become increasingly important and has attracted the attention of all sectors of society. Moreover, the digital economy has developed rapidly, and the digital transformation (DX) of enterprises is also an inevitable trend. Therefore, whether the DX of enterprises affects ESG performance is the core issue of this paper. On the basis of data from A-share listed companies in the Shanghai and Shenzhen stock markets from 2009--2023, the impact of the DX of enterprises on ESG performance is studied. In addition, the effects of lag periods and heterogeneity were also studied. The results show that the DX of enterprises has a significant positive effect on the ESG rating of enterprises and that there is a significant positive lag effect. Moreover, the DX of enterprises has a positive effect on environmental protection and social responsibility but a negative effect on corporate governance. Moreover, the heterogeneity analysis of the nature of property rights shows that the impact of the DX of nonstate-owned enterprises on the ESG performance of enterprises is more significant.

Keywords

ESG, digital transformation, heterogeneity, nature of property rights, lag test

1. Introduction

Since the United Nations Global Compact first proposed ESG in 2004, ESG performance has attracted the attention of people worldwide. Enterprises' attention and emphasis on ESG performance have also increased. Moreover, the digital economy has developed rapidly and expanded into all areas of economic and social development, becoming an important force for promoting social progress. DX has become a key to enhancing competitiveness and achieving sustainable development. DX provides efficient, convenient, and diverse digital technologies; optimizes cost structures and resource allocation; and innovates business models. In today's era of digital technology, can the DX of enterprises promote ESG performance and provide a reliable path for enterprises to achieve value maximization?

With respect to the impact of enterprise DX on ESG information disclosure, existing studies have revealed that (1) DX can improve the level of ESG information disclosure, enhance the comprehensiveness of information disclosure, alleviate the level of internal information asymmetry and improve ESG performance (Han & Zhang, 2023). (2) Other studies have shown that DX has a significant promoting effect on carbon information disclosure and that internal control quality and analyst attention play partial mediating roles in this process (Jian, 2024). (3) ESG performance plays a mediating role in the relationships between enterprise DX and inefficient investment, overinvestment, and underinvestment (Zhao & Zhang, 2024). (4) In addition,

relevant studies have shown that the digital economy can improve corporate governance levels by reducing information asymmetry and the irrationality of managers' decision-making behavior (Qi et al., 2020).

Overall, the academic community generally believes that DX can promote ESG performance, but empirical research on the impact of DX on ESG performance needs further supplementation. Therefore, this paper takes the data of Chinese Shanghai and Shenzhen A-share listed companies from 2009--2024 as the research object to study the impact of enterprise DX on ESG performance.

2. Theoretical Analysis

2.1 Environment

At the environmental level, an enterprise will inevitably cause various environmental pollution impacts during the production and manufacturing process. The enterprise needs to spend costs to offset the pollution caused by itself to the environment. In the context of DX, enterprises can introduce digital advanced technologies such as AI and big data to improve efficiency, conduct precise production and enhance green innovation capabilities to reduce environmental pollution (Wu & Li, 2023). In addition, DX promotes the emergence of network data sharing platforms, through which companies can search and analyse various data to observe policy change trends in advance, enhancing the information interaction between the internal management team and the external policy environment, and the company can better adjust its production methods, product directions, etc., according to policy trends and increase its performance in the environmental field.

2.2 Social Responsibility

Most companies usually enhance their reputation and popularity by conducting charitable activities and other public welfare activities. In the digital era, this influence is more obvious because DX promotes the emergence of network data sharing platforms, which are used by enterprises to establish connections with potential partners and professional clients. External institutions such as the government can more conveniently obtain information to assess the scale and contribution of a company's charitable activities (Dinu et al., 2022). Therefore, companies are more willing to disclose their charitable and other social responsibility activities to enhance their social responsibility performance.

2.3 Corporate Governance

The performance of corporate governance refers to whether a company can meet the needs of various stakeholders. The DX can convert the economic situation and operational situation within the enterprise into data and convert the needs and expectations of employees, external investors, etc., through cloud collection into data. A company can better meet the needs and expectations of employees and external investors by analysing these data. External investors and employers can also clearly know the operational situation of each company through data, thereby making more correct decisions in investment and employment. In addition, digital technology can identify financial anomalies and vulnerabilities in real time, increase compliance with corporate governance (Chen et al., 2019), and improve corporate governance performance naturally.

2.4 Challenge

Within enterprises, issues such as immature digital technology, high investment costs and untimely adjustment of the governance structure may hinder the progress of digital transformation. In terms of the external environment, factors such as incomplete policies and regulations may also restrict the improvement of ESG performance through digital transformation for enterprises.

In summary, DX can improve ESG performance by reducing the environmental cost and asymmetry of internal and external information of the company, increasing the reputation and popularity of the company to promote maximum benefits. On the basis of the above analysis, we propose the following hypotheses:

H1: The digital transformation of enterprises can promote their ESG performance.

3. Research Design

3.1 Data Sources

This paper selects the data of A-share listed companies on the Shanghai and Shenzhen stock exchanges from 2009--2024 as the initial research samples and processes the data as follows: first, financial enterprises are excluded; second, the samples of STs and those delisted during the period are eliminated; third, the samples with missing data for the main variable are excluded. Fourth, to reduce the impact of outliers, this paper performs 1% and 99% tailing on all continuous variables at the micro level. The original data are all from the CSMAR database, whereas the annual report data of related enterprises are from the official websites of the Shenzhen Stock Exchange and the Shanghai Stock Exchange.

3.2 Set Variable

3.2.1 Explained Variables

ESG performance (ESG) Huazheng's ESG ratings are divided into nine grades: AAA, AA, A, BBB, BB, B, CCC, CC, and C, with values assigned on a 100-point scale from high to low. The higher the score is, the better the ESG performance.

3.2.2 Explaining Variables

Enterprise digital transformation (DCG). At present, there is still no specific method for the quantitative measurement of the DCG. Since external personnel cannot have an in-depth understanding of the internal information of an enterprise, this article can measure only the degree of digitalization of an enterprise through its external information disclosure. This article crawled the annual reports of all A-share listed companies on the Shanghai Stock Exchange and the Shenzhen Stock Exchange via Python. Specific keywords related to DX are summarized and sorted from a series of classic studies on the theme of DX (Li et al., 2020; Ling et al., 2021; Wang & Guo, 2023). The frequency of occurrence of specific keywords related to DX and their proportion in all the terms of an enterprise's annual report represent the DCG.

3.2.3 Control Variables

To improve the accuracy of the research, a series of control variables were added to this paper. The variables include the CEO and chairperson of the board of directors' office performance ($Duaal$, CEO and chairperson of the board of directors have two parts-time = 1, otherwise = 0), total assets net profit margin (ROA, net income/total assets balance), asset–liability ratio (Lev, total liabilities/total assets), enterprise scale ($Size$, Ln(The project total assets)), sustainable growth rate ($Growth$), owners' equity (net income/total ending balance) * [1 - dividends per share pretax/(net current value/paid-in capital this final value)]/(1 -molecule), government subsidies ($Subsidy$, Government subsidy amount/operating income), etc.

3.3 Model Setting and Empirical Strategies

To study the effect of the DCG of enterprises on their ESG performance, the following formula is used for verification:

$$ESG_{i,t} = \varphi + \varphi_1 DCG_{i,t-1} + \sum \varphi_2 CVs + \sum years + \sum Inds + \varepsilon \quad (1)$$

The explained variable is the enterprise's ESG performance ($ESG_{i,t}$), and the core variable is the degree of digital transformation of the enterprise ($DCG_{i,t-1}$). Because DX influencing enterprises needs a certain amount of time, to explain the core variable lag phase 1 processing, we can solve the problem of transfer between variables in real time.

4. Empirical Analysis

4.1 Descriptive Statistical Analysis

The results are shown in Table 1. The mean value of ESG performance is 73.34, and the standard deviation is 4.736, indicating that there are significant differences in the ESG performance of the sample enterprises. The mean value of DCG is 1.469, and the standard deviation is 1.418, indicating that overall, our country is in the lower-middle range.

Table 1: Descriptive statistics.

Variable	N	Mean	p50	Min	Max	SD
ESG	33752	73.34	73.51	58.12	83.89	4.736
DCG	33752	1.469	1.099	0	5.037	1.418
Size	33752	22.19	21.99	19.93	26.08	1.270
Lev	33752	0.417	0.408	0.0509	0.922	0.209
Dual	33752	1.698	2	1	2	0.459
Growth	33752	0.0420	0.0478	-0.539	0.374	0.115
soe	33752	0.339	0	0	1	0.473
Subsidy	33752	1.100e+07	700000	1600	2.700e+08	3.500e+07
ROA	33752	0.0371	0.0382	-0.244	0.202	0.0633
E score	33752	60.97	60.70	45.76	80.45	7.020
S score	33752	74.78	75.58	47.22	100	8.732
G score	33752	79.38	80.64	55.06	90.92	6.328

4.2 Benchmark Regression

Table 2 reports the core test results of the relationship between an enterprise's DX and its ESG performance. This paper employs the stepwise regression method for regression tests. In Model (1), only time and industry fixed effects were controlled. The regression coefficient between the enterprise ESG index and the degree of digitalization (DCG) was 0.1303, and it passed the 1% statistical significance test, indicating that DX has a significant positive impact on ESG performance, preliminarily verifying Hypothesis 1. Models (2) and (3) add more control variables, and both pass the 5% statistical significance test. Thus, the assumption of this article holds true.

Table 2: Benchmark regression results.

	(1)	(2)	(3)
	ESG	ESG	ESG
DCG	0.1303***	0.1029**	0.0959**
	(2.5840)	(2.2552)	(2.1073)
ROA		12.8090***	12.8010***
		(7.7100)	(7.7400)
Lev		-4.4779***	-4.4575***
		(-12.3972)	(-12.3508)
Size		0.8905***	0.8449***
		(13.8018)	(13.0160)
Growth		-0.7212	-0.8056
		(-0.6997)	(-0.7853)
Dual			-0.2126**
			(-2.2360)
Subsidy			0.0000***
			(3.8356)
industry	Control	Control	Control
year	Control	Control	Control
_cons	73.5782***	55.2267***	56.5109***
	(748.7974)	(41.0969)	(42.1429)
N	18487	18487	18487
r2_a	0.0645	0.1553	0.1570

t statistics in parentheses.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

4.3 Robustness Test

4.3.1 Delete Some Samples

In reality, time series data are often affected by sudden or extreme events. These factors may cause the data of certain years to present abnormal characteristics. The period of the study included unexpected events such as the COVID-19 pandemic. Therefore, some years from the sample (2019, 2020, 2010, 2019, and 2014) are randomly deleted to observe whether the model results still hold, which can be used to determine whether the conclusion is driven by abnormal events. This can reduce sample dependence and enhance the credibility of the conclusion. As shown in Table 3, the correlation regression coefficient between an enterprise's ESG performance and DCG is 0.1396, passing the 1% significance test. Thus, the core conclusion still holds.

Table 3: Robustness test: Delete some samples.

	(1)	(2)	(3)
	ESG	ESG	ESG
DCG	0.1664***	0.1469***	0.1396***
	(3.3759)	(3.3172)	(3.1622)
Growth		-0.4847	-0.5723
		(-0.4682)	(-0.5557)
Size		0.9408***	0.8967***
		(14.9332)	(14.0779)
Lev		-4.7360***	-4.7165***
		(-13.4991)	(-13.4637)
ROA		12.0299***	12.0480***
		(7.3848)	(7.4258)
Dual			-0.2126**
			(-2.3353)
Subsidy			0.0000***
			(3.7139)
industry	Control	Control	Control
year	Control	Control	Control
_cons	73.5189***	54.1689***	55.4210***
	(745.1467)	(41.3535)	(42.1527)
N	14996	14996	14996
r2_a	0.0683	0.1708	0.1726

t statistics in parentheses.

* p < 0.1, ** p < 0.05, *** p < 0.01.

4.3.2 Lag Period Robustness Test

This article extends the time window for examining the impact of DX on the ESG ratings of enterprises. This paper lags the core explained variable by 1--3 years. If the regression coefficient between DCG and ESG remains consistent in significance under different lag periods, the conclusion cannot rely on specific lag settings and is more reliable.

As shown in Table 4, after lagging ESG performance by one or two years, the impact of corporate DCG on the ESG performance of enterprises has a significant positive effect. However, after a lag of three years, the DCG of enterprises no longer has a significant effect on their ESG ratings. This might be because, in the early stage of DX, enterprises rapidly improved their ESG through green innovation and increasing information disclosure quality, but after exceeding the threshold, their performance declined due to the resource occupation effect (Zhang & Zhao, 2025). Therefore, DX will only have a significant positive effect on ESG ratings in the short term.

Table 4: Robustness test: Hysteresis regression

	lagESG	lagESG2	lagESG3
DCG	0.0900*	0.1298*	0.0441
	(1.6758)	(1.8953)	(0.5881)
Growth	-1.9856*	-0.2641	-4.6665***
	(-1.7272)	(-0.1652)	(-2.9243)

Size	0.7146***	0.7338***	0.5464***
	(9.4032)	(7.5439)	(5.0847)
Lev	-3.8818***	8.5041***	-2.1311***
	(-9.2434)	(3.4600)	(-3.5627)
ROA	11.9182***	-3.6336***	14.2900***
	(6.4363)	(-6.9142)	(5.4447)
Dual	-0.1641	0.0000	-0.0433
	(-1.4569)	(0.6122)	(-0.2692)
Subsidy	0.0000***	-0.0629	0.0000***
	(3.9055)	(-0.4406)	(2.6333)
industry	Control	Control	Control
year	Control	Control	Control
_cons	59.1233***	58.5580***	62.0158***
	(37.6299)	(28.9895)	(27.6983)
N	13111	6362	8261
r2_a	0.1295	0.1042	0.1182

t statistics in parentheses.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

4.4 Molecular Sample Regression

ESG dimensions may have endogenous correlations. This test can eliminate interference from other dimensions and enhance the credibility of the results. Therefore, this paper studies the influence of DCG on the scores of E, S, and G. Table 5 shows that a company's DCG has a significant positive relationship with the S score (social responsibility), but its positive effect on the E score (environment) is not significant. This might be because DX requires a large amount of capital investment, thereby squeezing the company's green innovation investment (Yang et al., 2024). The G score (corporate governance) is negatively correlated with the degree of DCG. This might be because DX, by reducing information costs, promotes decision-making power for subsidiaries, leading to a decentralized governance structure (Duan et al., 2023;Rahman & Mehnaz, 2024).

Table 5: Robustness test: Molecular sample regression.

	E score	S score	G score
DCG	0.0404	0.2812***	-0.0483
	(0.6354)	(4.1769)	(-0.8448)
Growth	-0.8852	-0.0930	1.1433
	(-0.6658)	(-0.0635)	(0.7593)
Size	1.2287***	0.9955***	0.6097***
	(12.9089)	(10.5224)	(7.0176)
Lev	1.0275**	1.9314***	-11.9992***
	(2.0181)	(4.0037)	(-23.6400)
ROA	4.1633*	11.1933***	16.7685***
	(1.8273)	(4.8053)	(7.1960)
Dual	0.1824	-0.2317	-0.4240***
	(1.2799)	(-1.6335)	(-3.5722)
Subsidy	0.0000***	0.0000	0.0000**
	(3.9764)	(0.8607)	(2.3009)
Industry	Control	Control	Control
year	Control	Control	Control
_cons	33.6329***	53.1240***	70.4641***
	(17.0586)	(27.0090)	(39.6744)
N	14996	14996	14996
r2_a	0.1584	0.1859	0.2704

t statistics in parentheses.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

4.5 Heterogeneity Test

Under different enterprise attributes, DX has different impacts on its ESG rating. This study divides the entire sample into state-owned enterprises (Soe=1) and nonstate-owned enterprises (Soe=0). A subsample test was conducted. Table 6 shows that in state-owned enterprises, the positive relationship between the DCG of enterprises and their ESG ratings did not pass the significance test. However, for nonstate-owned enterprises, DCG had a positive effect on ESG performance and passed the 1% significance test. This might be because a core motivation for the DX of nonstate-owned enterprises is obtaining a "brand premium" and "financing convenience" through ESG (Fu, 2024). State-owned enterprises are more likely to obtain financial support. Investors' requirements for their ESG focus more on compliance rather than excess returns. Therefore, the market-driven attribute of ESGs in DX is relatively weak, and it is more reflected in the drive of policy compliance [16].

Table 6: Heterogeneity test for state ownership.

	Soe=1	Soe=0
	ESG	ESG
DCG	0.1220	0.1393***
	(1.0313)	(3.0280)
Growth	0.4070	-0.2915
	(0.1793)	(-0.2634)
Size	1.2524***	0.7636***
	(9.9499)	(10.2882)
Lev	-4.9434***	-4.6392***
	(-5.7238)	(-12.4084)
ROA	8.9859**	11.9475***
	(2.1853)	(6.9069)
Dual	0.0055	-0.2446**
	(0.0172)	(-2.5568)
Subsidy	0.0000**	0.0000***
	(2.3661)	(2.8167)
industry	Control	Control
year	Control	Control
_cons	47.3401***	58.3175***
	(17.3336)	(37.9890)
N	1923	13071
r2_a	0.2902	0.1655

t statistics in parentheses.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

5. Conclusion

Today, the new model of "physical-digital deep integration" fuels China's growth. This article focuses on the correlation between DCG and ESG ratings. We selected A-share listed companies on the Shanghai and Shenzhen stock exchanges in China from 2009--2023 as samples. We collected the annual reports of all sample companies through Python and extracted and processed the relevant keywords related to "digital transformation" in the reports to quantify DCG. On this basis, empirical analysis methods were used to examine the relationship between DCG ratings and ESG ratings. After data analysis and demonstration, the main results are as follows.

First, the DX of enterprises can promote their ESG performance. The higher the DCG is, the higher the ESG rating. Second, DX will only have a significant positive effect on ESG ratings in the short term. Third, the higher the DX is, the better it performs in terms of social responsibility. However, the slightly worse the corporate governance level of an enterprise is. Fourth, the effect is asymmetric under the different attribute characteristics of different enterprises: the DX of nonstate-owned enterprises can better promote the ESG rating of enterprises.

This article has the following policy implications. First, the digital transformation of enterprises should be comprehensively promoted, their fundamental enabling role in ESG performance should be strengthened, and more enterprises should be encouraged to enhance their ESG performance through digital tools. Second, in response to the "short-term" impact of digital transformation on ESG performance, the "phased guidance" of policies should be strengthened. For example, implementing "dynamic assessment" or encouraging enterprises to further upgrade. Third, in response to the issue of the decline in G scores, the government can require enterprises to improve their data security governance and incorporate "governance compliance" into the acceptance criteria for digital transformation. Fourth, on the basis of the "asymmetric effect" of enterprise attributes, "differentiated policy support" should be implemented. State-owned enterprises should add the indicator of "actual contribution of DX to ESG" to the existing assessment and force state-owned enterprises to invest more digital resources in the improvement of the ESG dimension. Moreover, the capital market continues to be guided to link ESG performance with financing costs, enabling nonstate-owned enterprises to benefit directly from ESG improvement through DX.

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