

Exploring the Mechanisms of Corporate Digital Transformation's Impact on ESG Performance in the Context of Dual Carbon Goals: Evidence from China

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Abstract: Drawing from the 2015-2021 panel data of China's A-share listed companies, this study employs multiple regression analysis to assess the impact of corporate digital transformation (CDT) on ESG performance. Findings suggest a significant positive correlation between the degree of CDT and ESG outcomes. As CDT intensifies, there's a marked improvement in ESG performance. Further analysis uncovers a threshold effect in this relationship, implying the most pronounced positive influence on ESG emerges after reaching a certain level of digital transformation. Robustness checks confirm these core findings. Moreover, the level of corporate profitability doesn't mitigate the positive correlation between CDT and ESG performance. This positive relationship remains significantly evident across both state-owned and private enterprises, with a heightened correlation observed in the state-owned segment. This research enriches the theoretical understanding of the nexus between digital transformation and corporate social responsibility, buttressed by empirical evidence.

Keywords: Corporate Digital Transformation; ESG Performance; Threshold Effect

1. Introduction

In recent years, the intersection of corporate digital transformation (CDT) and environmental, social, and governance (ESG) performance has emerged as a pivotal area of study within the business and environmental management fields. This growing interest is underscored by the dual carbon goals set forth by countries worldwide, aiming for carbon neutrality and a reduction in greenhouse gas emissions. The digital economy development strategy and the concept of green transformation have highlighted the potential of digital technologies to enhance corporate competitiveness through improved ESG performance (Fan et al., 2023) [1]. Research by Ding et al. (2024) [2] and Chen et al. (2024) [3] suggests that digital transformation not only enhances total factor productivity but also has a significant positive impact on ESG performance, thereby contributing to sustainable economic systems. However, the literature reveals a complex and nuanced relationship between CDT and ESG performance. Studies like that of Wang et al. (2024) [4] and Hou et al. (2024) [5] have begun to unpack these dynamics, indicating a significant positive influence of digital transformation on green technology innovation and various ESG dimensions. Despite these advances, the mechanisms through which CDT influences ESG performance, particularly in the context of China's fast-paced digital economy and stringent environmental regulations, remain insufficiently explored (Lu et al., 2023) [6]. Moreover, empirical evidence on the mediating roles of factors such as firm innovation, efficiency, and corporate governance within this relationship is still emerging. The literature points to the potential of digital finance to promote firm ESG performance (Xue et al., 2023) [7], and the mixed effects of digital transformation efforts across different sectors and firm types (Miao et al., 2023) [8].

Given this backdrop, our study seeks to fill the gap in the literature by investigating the mechanisms through which corporate digital transformation impacts ESG performance in the specific context of China's dual carbon goals. By leveraging a robust dataset of Chinese A-share listed companies and employing advanced econometric techniques, we aim to provide nuanced insights into how digital transformation can serve as a lever for enhancing ESG performance, taking into account various moderating factors such as firm size, industry type, and ownership structure. In

doing so, this study contributes to the theoretical understanding of the digital-ESG nexus and offers practical implications for policymakers and corporate managers aiming to align digital transformation initiatives with sustainability goals. Research Hypotheses:

H1: There is a direct positive relationship between corporate digital transformation and ESG performance among Chinese A-share listed companies. H2: The relationship between corporate digital transformation and ESG performance exhibits a threshold effect, where the positive impact intensifies beyond a certain level of digital transformation

2. Research Design

This study investigates the impact of corporate digital transformation on ESG performance among Shanghai and Shenzhen A-share listed companies from 2015 to 2021, excluding firms under Special Treatment (ST) status, those with listing interruptions, or listed for less than three years. Continuous variables were winsorized at the 1% tails to reduce outlier effects. Data sources include financial and governance information from the CSMAR database, ESG performance from the Huazheng ESG rating system, and digital transformation metrics derived from text analysis of annual reports. The final sample comprised 24,643 firms. The dependent variable, ESG performance, utilizes the Huazheng ESG rating system's nine-level scores. The key independent variable is a digital transformation index created from company reports, using a log-transformed combined index for analysis. Control variables such as firm size, age, growth rate, asset-liability ratio, independent director ratio, equity concentration, and board size are included to account for other influences on firm performance. In order to test the hypotheses, this study develops a first baseline model. Benchmark Regression Model:

$$ESG_{i,t} = \beta_0 + \beta_1 \times DT_{i,t} + \beta_2 \times \text{Control Variables}_{i,t} + \epsilon_{i,t} \quad (1)$$

$ESG_{i,t}$ denotes the ESG score of firm i at time t . $DT_{i,t}$ represents the digital transformation measure for firm i at time t . $\text{Control Variables}_{i,t}$ encompasses other control variables, including Size, Lev, Growth, Board, Indep, and Top1. $\epsilon_{i,t}$ is the error term.

Table 1. Definitions of main variables

Variable Name	Variable Classification	Variable Definition
ESG	Dependent variable	ESG Rating Assignment 1-9 Points
DT	Independent variable	Sum of Digital Transformation Level-
Size	Control variable	Total corporate assets
Age		$\ln(\text{current year} - \text{year of listing} + 1)$
Growth		$(\text{Current period's operating income} - \text{previous period's operating income}) / \text{previous period's operating income}$
Lev		Total corporate liabilities / Total corporate assets
Indep		Number of independent directors / Number of directors
Top1		Shareholding ratio of the first largest shareholder
Board		$\ln(\text{Number of directors})$

3. Analysis of regression results

3.1 Descriptive statistical analysis

The average company size is around 23.11, mostly centered around the mean. Operating income growth has fluctuations, with some companies showing revenue drops. The average debt-to-asset ratio is 0.486. The proportion of independent directors' averages at 0.378 with minor variations. Equity concentration varies, while the average board size stands at 2.149 with little fluctuation. The digital transformation degree shows significant diversity among companies. The average ESG score is 4.295 with some variability.

Table 2. Descriptive statistics of main variables

Variable	Sample value	Mean	Standard deviation	Minimum value	Maximum value
Size	24,643	23.109	1.417	19.716	26.430
Growth	24,643	0.184	0.427	-0.660	4.330
Lev	24,643	0.486	0.188	0.054	0.906
Indep	24,643	0.378	0.058	0.286	0.600
Top1	24,643	0.336	0.150	0.081	0.743
Board	24,643	2.149	0.203	1.609	2.708
DT	24,643	67.322	111.999	0.000	1470.000
ESG	24,643	4.295	1.081	1.000	7.750

3.2 Analysis of baseline regression results

The coefficient for DT (Degree of Digital Transformation) is 0.0935 and is highly significant ($p < 0.001$), indicating a positive correlation between the degree of digital transformation and ESG scores, consistent with the first hypothesis (H1) of this study. Most of the control variables (Size, Lev, Growth, Indep, Top1) also significantly influence the ESG score, with only the Board variable being not significant.

Table 3. Results of benchmark regression tests

Variable	
DT	0.0935***
Size	0.3535***
Lev	-1.2191***
Growth	-0.1520***
Board	-0.0065
Indep	1.2667***
Top1	-0.1504***

Note: *** means significant at 1% level of significance, ** means significant at 5% level of significance, * means significant at 10% level of significance.

3.3 Quantile regression analysis

$$Q_1(ESG_{i,t}|X_{i,t}) = \beta_0(1) + \beta_1(1) \times DT_{i,t} + \beta_2(1) \times \text{Control Variables}_{i,t} \quad (2)$$

$Q_1(ESG_{i,t}|X_{i,t})$ represents the I quantile of the dependent variable, given the covariates $ESG_{i,t}$, I is the threshold value. $\beta_0(1)$, $\beta_1(1)$, $\beta_2(1)$ are the quantile regression coefficients, describing the impact of the explanatory variables on the dependent variable at the I quantile.

Table 4. Quartile regression test results

Variable	25 percentile	50 percentile	75th percentile
DT	0.086***	0.096***	0.099***

Size	0.371***	0.369***	0.319***
Lev	-1.434***	-1.299***	-0.868***
Growth	-0.147***	-0.145***	-0.129***
Board	-0.001	-0.066	-0.036
Indep	1.010***	0.712***	1.247***
Top1	-0.051	-0.190***	-0.149***

In all considered quantiles (25th, 50th, 75th), the degree of digital transformation (DT) is positively correlated with ESG scores and is statistically significant. The positive impact of digital transformation is strongest at the median ESG score (50th percentile) with a coefficient of 0.1052. This indicates that among companies with medium ESG scores, the positive correlation between DT and ESG is most pronounced. Data analysis reveals a positive relationship between digital transformation and corporate ESG scores, with varying impacts across different ESG percentiles. These findings support the research hypothesis that digital transformation positively affects corporate ESG scores, and a threshold effect may exist.

4. Robustness test

4.1 Bootstrap

This study, through 5,000 iterations of the bootstrap method, obtained an average coefficient estimate for DT of 0.084, which is very close to the original OLS regression result (0.083). This indicates that in different sub-samples (drawn through bootstrap), the coefficient estimate for DT is relatively stable and does not fluctuate greatly with minor changes in the sample. Furthermore, the 95% confidence interval for DT is [0.071, 0.094], which does not include 0, further confirming that the positive correlation between DT and ESG is statistically significant.

Table5. Bootstrap Test Method

Variable	Average percentile	2.5% percentile	97.5% percentile
DT	0.084***	0.071	0.094
Size	0.335	0.323	0.349
Lev	-1.203	-1.281	-1.139
Growth	-0.180	-0.208	-0.152
Board	0.043	-0.034	0.107
Indep	1.299	1.026	1.493
Top1	-0.264	-0.369	-0.178

4.2 Multiple covariance test

This study calculates the Variance Inflation Factor (VIF) for each variable. VIF serves as an indicator to measure the degree of multicollinearity. A higher VIF value suggests higher collinearity of that variable with other variables. Generally, a VIF value exceeding 10 may indicate severe multicollinearity issues. The results show that the VIF values for all variables are well below 10, indicating no significant multicollinearity concerns.

Table6. VIF Test Method

Variable	VIF
DT	1.044
Size	1.694
Lev	1.404
Growth	1.006
Board	1.511
Indep	1.402
Top1	1.132

5. Heterogeneity tests

5.1 Test of the nature of the enterprise's ownership

The present study here develops a third model

$$ESG_{i,t} = \beta_0 + \beta_1 \times DT_{i,t} + \beta_2 \times SOE_{i,t} + \beta_3 \times DT_{i,t} \times SOE_{i,t} + \beta_4 \times \text{Control Variables}_{i,t} + \epsilon_{i,t} \quad (3)$$

SOE_{it} is a binary variable that takes the value 1 if firm i is a state-owned enterprise at time t and 0 otherwise.

Table 7. Results of Business Ownership Test

Variable	SOE (1)	SOE (0)
DT	0.082***	0.084***
Size	0.322***	0.314***
Lev	-1.192***	-1.198***
Growth	-0.140***	-0.138***
Board	0.038***	0.035***
Indep	1.134***	1.139***
Top1	-0.209***	-0.211***

5.2 Test for Differences in Profit Levels of Firms

Regarding the heterogeneity test results, this study constructed a binary variable "Profit Level" to distinguish companies with high and low profitability. An interaction term, DT_Profit_Level , was introduced to test the moderating effect of a company's profitability level on the relationship between digital transformation and ESG. The results show that the coefficient for DT_Profit_Level is not significant (p-value=0.888), indicating that the impact of digital transformation on ESG does not differ significantly between companies of varying profitability levels.

Table 8. Results of the test for differences in profit levels of firms

Variable	
DT	0.0008***
Size	0.3387***
Lev	-1.1263***
Growth	-0.1980***
Board	0.0001
Indep	1.3437***
Top1	-0.2312***
Profit_Level	0.2590***
DT_Profit_Level	-0.0000

6. Conclusions

Utilizing panel data from China's A-share listed companies (2015-2021), this research examines the link between corporate digital transformation (CDT) and ESG performance. We hypothesize (H1) a direct positive relationship between CDT and ESG, and (H2) a threshold effect after reaching a digital transformation level influencing ESG. Our regression analyses reveal a strong correlation between CDT and ESG scores, affirming H1. Notably, the influence is most evident for firms with medium ESG standings, validating H2. Heterogeneity tests highlight the pronounced positive association in state-owned firms, suggesting their pronounced benefit from digital transformation in elevating ESG performance. Interestingly, high-profit firms don't showcase significant ESG enhancement via digitalization. The results emphasize the broad benefit of digital transformation on ESG performance across profitability spectrums. This enriches the theoretical understanding of the link between digital transformation and corporate social responsibility. It provides a policy foundation for government bodies aiming to uplift corporate social responsibility, emphasizing support for companies with lower digital transformation levels. For corporate

management practices, digital transformation should be perceived as a pivotal avenue to enhance corporate social responsibility.

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