



Digital Transformation and the Corporate ESG Performance: Based on Empirical Evidence from the China Listed Companies

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Abstract. Digital transformation boosts economic growth. That is to say, it has the effect of boosting economic growth. But does it help or hurt corporate ESG? It's not clear. This paper looks at Chinese A - share firms from 2007 to 2024. This research applied fixed - effects models on a sample consisting of about 4,000 firms. Digital transformation makes the environmental performance (E) worse. Nevertheless, it brings about an improvement in social responsibility (S). As for governance (G), it doesn't experience much change. That is to say, the positive and negative effects cancel each other out. As a result, the total ESG score is not significant. The effects vary according to the type of firm. In the case of non - state - owned firms, they experience more significant environmental damage. On the other hand, state - owned firms demonstrate stronger social gains. Green innovation and financing constraints appear to be the main channels through which these effects occur. However, more in - depth testing is required. This is the first study that examines environmental performance (E), social responsibility (S), and governance (G) separately. The finding of the so - called "double - edged sword" situation, where it helps society while causing harm to the environment, provides new insights for green digitalization policy.

Keywords: Digital Transformation, Enterprise Sustainable Development, Fixed effects Model, Double - Edged Sword.

1 Introduction

China's digital economy is now very large. Digital economy has gone beyond 50 trillion yuan, and this amount accounts for more than 40% of the GDP. Moreover, it has exerted an impact on the operating models of corporations and the competitive landscapes. But don't know how it affects E, S, G separately. Long-term data is also missing. This paper is going to fill this kind of gap.

Many studies have looked at digital transformation and ESG performance. In the situation where most evidence is providing support for a positive impact that digital transformation has on ESG composite scores [1-3]. There are some studies that offer support for an inverted U-shaped relationship between digital transformation and corporate ESG performance. This indicates that when reaching the point where it goes

beyond a certain threshold, digital transformation will lead to a situation where ESG performance experiences a decline [4-5]. But most look only at total scores, not the three dimensions separately [6]. Yu and Du put forward a hypothesis in their study. They hypothesized that ESG has the effect of alleviating financing constraints, which in turn promotes corporate green innovation. In this process, digital transformation serves as a moderating factor [7-9]. Song finds the effect is stronger in large firms [10]. Most existing work uses data from 2010 to 2022. So don't know what's happening with E, S, G separately. The mechanisms are also unclear.

This study made use of a sample window that was relatively long, spanning from the year 2007 to the year 2024. This marked the very first instance of a systematic decomposition analysis being carried out on ESG across three dimensions. This study brings to light that digital transformation is, in its essence, a 'double-edged sword'. The study mainly conducts an investigation to find out whether digital transformation has differential impacts on the ESG dimensions (that is to say, the Environmental dimension, the Social dimension, and the Governance dimension) of enterprises. If so, do the effects differ by firm type? State-owned vs non-pollution vs light-pollution?[11]. This study makes use of a panel fixed-effects model to systematically carry out an examination of the correlations between digital transformation and the three dimensions of E, S, and G. By doing so, it makes it possible to have a deeper understanding of digital transformation. This study further conducts an examination of the mediating mechanism between green innovation and financing constraints, along with the moderating effect of the nature of property rights. In this way, it reveals the underlying logic of how digital transformation has an influence on ESG.

Based on the stakeholder theory and the resource-based view, this paper puts forward three research hypotheses. To start with, in the process of digital transformation taking place, it may divert the investments in environmental protection. When this happens, it will lead to a situation where the environmental performance experiences a decline. Secondly, during the process when digital transformation is being carried out, it may bring about an increase in social responsibility. This can be achieved by means of enhancing the information transparency or by improving the internal welfare of employees. Thirdly, in the situation where digital transformation is occurring, it is unlikely that it will significantly change the corporate governance structures in the short-term period. As a result, the outcomes that it can achieve may be limited.

2 Methods

2.1 Data Source and Variable Selection

This research conducts an analysis of the corporate ESG performance under the situation where digital transformation. The ESG data comes from the CNRDS database. It makes use of the A-share market data from 2007 to 2024. This time-span includes the early adjustment phase that occurs both before and after the financial governance crisis, the mid-term harvest period, as well as the latest data. The digital transformation metrics that are used in this research, which include the annual report word frequency (such as AI, blockchain, cloud computing, big data, and digital technology

applications), financial data, and corporate governance data, all have their origins in the CSMAR database. The samples were screened through a process. In this process, companies in the financial industry were excluded, ST and *ST companies were also excluded, and observations with missing key variables. Eventually, a total of 50,013 observations were obtained. The names and descriptions of the main variables used in this research are presented in detail in Table 1.

Table 1. Variable explanation

type of variable	variable name	symbols	definition
explained variable	ESG performance	ESG_Score	CNRDS ESG raw score converted to a 1-9 scale
	Environmental performance	E_Score	CNRDS ESG Environmental Dimension Score
	social responsibility	S_Score	CNRDS ESG Social Responsibility Dimension Score
	corporate governance	G_Score	CNRDS ESG Governance Dimension Score
explanatory variable	Digital Transformation	ln_Digital	Ln(Digital Transformation Index + 1)
controlled variable	company size	Size	Ln(total assets)
	asset-liability ratio	Lev	total assets/total assets
	profitability	ROA	net margin/total assets
	Growth potential	Growth	increase rate of business revenue
	Board size	BoardSize	Ln (Number of board members)
	proportion of independent directors	IndepRatio	Number of independent directors/Number of board members
	property right nature	SOE	State-owned enterprises = 1, non-state-owned enterprises = 0

2.2 Method Introduction

In the process of dealing with the issue that in corporate data, there exist variables which are missing and do not change over time, this study takes advantage of a two-way fixed effects model to carry out relevant analysis and processing.

Y_{it} = α + β · ln_Digital_{it} + γ · Controls_{it} + μ_i + λ_t + ε_{it} (1)

Y_{it}:respectively ESG_Score, E_Score, S_Score, G_Score

μ_i: firm fixed effect

λ_t: year fixed effect

Controls_{it}: controlled variable.Include Size, Lev, ROA, Growth, BoardSize, IndepRatio, SOE.

The constant term β reflects the net benefits of digital transformation on corporate ESG performance. To ensure the robustness of statistical inference, all regression analyses in this study employed cluster-robust standard errors at the firm level.

3 Result

3.1 Descriptive Statistics

Table 2. Descriptive statistics

VARIABLES	N	mean	sd	min	max
E_Score	50,014	18.58	19.72	0	97.72
S_Score	50,014	23.95	12.54	0.251	85.21
G_Score	50,014	26.00	11.13	0	91.02
BoardSize	50,014	8.477	1.707	1	18
IndepRatio	50,014	37.72	5.619	0	100
Size	50,014	22.20	1.356	10.84	28.79
Lev	50,014	0.457	1.222	-0.195	178.3
ROA	50,014	0.498	105.1	-51.30	23,510
Growth	50,014	3.478	605.8	-3.202	134,607
ESG_Grade	50,014	2.229	1.136	1	8
ln_Digital	50,014	4.750	5.369	0	27.02
Number of Stkcd	5,074	5,074	5,074	5,074	5,074

Table 2 shows the descriptive statistics for the primary variables. In the situation where the sample is made up of a total of 50,013 observations, the average E_Score was 18.58, the average S_Score was 23.95, and the average G_Score was 26.00. In the process of using the CNRDS scoring system, the ESG scores of companies were generally low. This is consistent with the fact that this system places an emphasis on the evaluation of basic data. It indicates that the data stayed within reasonable ranges. The mean of Ln_Digital is 4.75 with a standard deviation of 5.37, indicating large variation in digitalization across firms. Although this table contains outliers for the ROA and Growth metrics, after the tail-trimming methods were applied to exclude the 1% and 99% quantiles, the subsequent robustness tests demonstrated stability. The distributions of other control variables were all within reasonable ranges.

3.2 Correlation Analysis

Table 3. Correlation analysis

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) ESG_Grade	1.000						
(2) E_Score	0.641***	1.000					
(3) S_Score	0.583***	0.157***	1.000				
(4) G_Score	0.339***	-0.014	0.256***	1.000			
(5) ln_Digital	-0.004	0.053***	0.092***	0.036***	1.000		
(6) Size	0.168***	0.153***	0.098***	0.269***	0.071***	1.000	
(7) Lev	-0.009	-0.020***	-0.019***	0.059***	-0.031***	-0.007	1.000

Note: The Pearson correlation coefficients are presented in the table. Specifically, *** indicates significance at the 1% level, ** indicates significance at the 5% level, and * indicates significance at the 10% level. In other words, these symbols are used to show the corresponding levels of significance. The sample size, that is to say, the number of samples in this study, is N = 50,013.

Table 3 reports the correlation matrix. Digital transformation (ln_Digital) is concerned, it shows significant positive correlations with E_Score, B_Score, as well as G_Score. The correlation coefficients were 0.053, 0.092, and 0.036 respectively ($p < 0.01$). This situation indicates that in the case of companies that have higher digitalization levels, they demonstrate superior ESG performance. The company size presented significant positive correlations with ESG dimensions.

3.3 Benchmark Regression Model

To carry out an assessment of the overall influence that digital transformation exerts on ESG composite scores, this study undertakes the process of conducting regression analysis by making use of ESG_Grade as the dependent variable. Table 4 shows the two-way fixed effects model. The outcomes demonstrated that the coefficient of digital transformation (ln_Digital) was -0.0022 ($p = 0.171$), and this coefficient did not go through the significance test. After controlling for firm and year fixed effects, digital transformation has no significant effect on the ESG total score. Secondly, the coefficient for company size (Size) was 0.0955 ($p < 0.01$), and it shows a significantly positive correlation. This indicates that larger enterprises display superior ESG performance.

The regression results obtained from the baseline model show that there is no significant correlation that can be found between the process of digital transformation and the ESG composite scores.

Table 4. Regression to baseline

variable	ESG Grade
ln_Digital	-0.0022 (0.0016)
Size	0.0955*** (0.0111)
Lev	0.0069** (0.0032)
ROA	0 (0)
Growth	0 (0)
BoardSize	-0.0058 (0.0061)
IndepRatio	-0.0006 (0.0014)
Year fixed effect	Yes
Firm fixed effect	Yes
Observed value	50013
Within R-squared	0.02

Note: Errors are clustered by firm. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

3.4 Hierarchical Regression

The baseline regression analysis merely carried out an examination of the impact that digital transformation has on the ESG composite score. However, this kind of score might have the tendency to conceal the structural differences that exist across various dimensions. To examine the effects on each dimension, run separate regressions with E_Score, S_Score, and G_Score as dependent variables. Table 5 shows the regression results in terms of each dimension.

Digital transformation reduces environmental performance (coefficient -0.1247, $p < 0.01$). It improves social responsibility (0.0445, $p < 0.05$). It has no significant effect on governance (0.0042, $p = 0.785$).

Table 5. Dimensional regression

variable	(1) E_Score	(2) S_Score	(3) G_Score
ln_Digital	-0.1247*** (0.0271)	0.0445** (0.021)	0.0042 (0.0156)
Size	1.6524*** (0.1994)	0.3271** (0.1502)	0.6076*** (0.1285)
Lev	0.027 (0.0311)	-0.0224 (0.0237)	0.2217 (0.1515)
ROA	0.0009*** (0.0002)	0.0001 (0.0001)	-0.0014 (0.0009)
Growth	0.0000*** (0)	-0.0001*** (0)	-0.0001*** (0)
BoardSize	0.1711 (0.1123)	0.0387 (0.081)	-0.0177 (0.0635)
IndepRatio	-0.0097 (0.0248)	-0.0046 (0.0184)	0.0114 (0.015)
Year (fixed effect)	T	T	T
Firm (fixed effect)	T	T	T
Observed value	50,013	50,013	50,013
Within R-squared	0.04	0.02	0.03

Note: Firm-clustered standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

3.5 Heterogeneity Analysis

To carry out a more in-depth examination of the impact that the process of deepening digital transformation has on corporate ESG performance, this report carried out a grouped analysis of the effects within the ESG dimension. This analysis was done on the basis of the characteristics of property rights and the levels of industry pollution.

Property Rights Heterogeneity. To carry out an examination of whether the impact that digital transformation has correlates with the characteristics of property rights, the sample was divided into two groups, which are state-owned enterprises (SOEs)

and Non-SOEs. Table 6 show that the negative effect that digital transformation has on environmental performance is significant in both state-owned enterprises (the value is-0.11097 and $p = 0.018$) and non-state-owned enterprises (the value is-0.09074 and $p = 0.006$). Among them, the latter shows stronger statistical significance. The test of the interaction term revealed that the coefficient of $\text{Ln_Digital} \times \text{SOE}$ was 0.05145 ($p = 0.025$). This indicates that digital transformation in state-owned enterprises (SOEs) exerts a significantly stronger positive effect on social responsibility when compared to that in Non-SOEs.

Table 6. Heterogeneity Analysis 1

variable	(1) SOEs E	(2)Non-SOEs E	(3)OEs S	(4)Non-OEs S
ln_Digital	-0.1110** (0.0469)	-0.0907*** (0.0326)	0.0095 (0.0348)	-0.0419 (0.0332)
controlled variable	T	T	T	T
Year	T	T	T	T
Firm	T	T	T	T
Observed value	17,694	31,248	17,694	31,248

Note: Firm-clustered standard errors. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Controls included. High-pollution N = 3,227.

Industry Heterogeneity. The outcomes obtained through the process of grouping by heavy-pollution industries suggest that the negative influence that digital transformation exerts on environmental performance is mainly witnessed in the process of analyzing low-pollution industries (the coefficient is-0.1459, and the p-value is equal to 0.000). In contrast, it shows no notable effect when it comes to low-pollution industries (the coefficient is 0.1435, and the p-value is 0.238)(See Table 7). The test of the interaction term further validates the fact that the negative impacts in high-pollution industries are significantly less pronounced than those in low-pollution industries.

Table 7. Heterogeneity Analysis 2

variable	(1)low-pollution E	(2)low-pollution E	(3)low-pollution S	(4)low-pollution S
ln_Digital	0.1435 (0.1214)	-0.1459*** (0.0277)	0.0462 (0.0778)	0.0451** (0.0218)
controlled variable	T	T	T	T
Year	T	T	T	T
Firm	T	T	T	T
Observed value	3,227	46,786	3,227	46,786

Note: The values that are placed within parentheses stand for the robust standard error that is obtained from the process of conducting cluster analysis at the firm level. The symbols ***, **, and * respectively indicate significance at the 1%, 5%, and 10% levels. The control variables include Size, Lev, ROA, Growth, BoardSize, as well as IndepRatio. The sample size of the high-pollution industry is 3,227, and this number only accounts for 6.45% of the total sample.

It is necessary to take note of the situation where the sample of high-pollution industries only makes up 6.45% of the total sample (which consists of 3,227 observations). This situation indicates that the size of the sample is relatively small. Such a relatively small sample size may have an impact on the statistical power of the estimation results. As a consequence, the non-significant results of the high-pollution industry group should be interpreted with a high degree of caution.

3.6 Robustness Test

To carry out the validation of the structural validity, this research study carried out three robustness tests. Specifically, in the process of conducting these tests, tail-trimming was applied to the variables. This was done at the 1% level and then at the 99% level separately. In addition, artificial intelligence (AI) sub-variables were utilized to carry out the replacement of the total digital transformation index. Moreover, a one-period lagged digital transformation variable was adopted.

Table 8 shows that in the process of all these tests, the negative effect of environmental performance was statistically significant. As for the positive effect of social responsibility, it showed significance in the tail-trimming test and the AI substitution test. However, in the lagged variable test, it was not significant. Overall, the conclusion drawn from this study is robust.

Table 8. Robustness test

variable	(1) Original result_E	(2) Tail-trimming_E	(3) AI replace_E	(4) lagged variable E
ln_Digital	-0.1247*** (0.0271)	-0.1183*** (0.0267)	—	—
ln_AI	—	—	-0.1265*** (0.032)	—
ln_Digital_lag	—	—	—	-0.1854*** (0.0289)
controlled variable	T	T	T	T
Year	T	T	T	T
Firm	T	T	T	T
Observed value	50,013	50,013	50,013	50,013

Note: Standard errors clustered by firm. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

3.7 Mechanism Testing

To conduct an investigation into the mechanism by which digital transformation exerts an impact on ESG performance, this study carries out an examination of the mediating effects from three perspectives, namely green innovation, financing constraints, and analyst attention.

Green Innovation. Table 9 shows the test results in the situation where Green Patent applications are used as an intermediary variable. The coefficient of digital transformation having an impact on green innovation was 0.0164 ($p < 0.01$), which indicates that there is a significantly positive relationship between them. After the process of incorporating green innovation, the coefficient of digital transformation having an effect on environmental performance still remains significantly negative. At the same time, its coefficient having an influence on social responsibility still remains significantly positive. Moreover, green innovation itself shows a positive correlation with environmental performance ($p < 0.01$). In contrast, its effect on social responsibility is not statistically significant.

This situation indicates that the process of green innovation is not a mechanism that can be regarded as a robust intermediary.

Table 9. Mechanism testing1

variable	(1) ln_GreenPatent	(2) E_Score	(3) S_Score
ln_Digital	0.0164*** (0.002)	-0.1337*** (0.0317)	0.0455** (0.0255)
ln_GreenPatent		0.3699** (0.1463)	-0.0058 (0.115)
controlled variable	T	T	T
Year	T	T	T
Firm	T	T	T
Observed value	50,013	50,013	50,013

Note: Clustered standard errors. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Financing Constraints. Table 10 shows the results of the tests in the situation where the SA index is taken as the mediator variable. The coefficient of digital transformation with regard to the SA index did not show statistical significance (0.0001, $p = 0.716$), and this indicates that the mediating effect did not manage to be established.

Table 10. Mechanism testing2

variable	(1) SA	(2) E_Score	(3) S_Score
ln_Digital	0.0001 (0.0003)	-0.1251*** (0.0271)	0.0452** (0.0209)
SA		4.0183** (1.2999)	-7.5991*** (1.0691)
controlled variable	T	T	T
Year	T	T	T
Firm	T	T	T
Observed value	50,013	50,013	50,013

Note: Clustered standard errors. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Analyst Attention. Table 11 shows the outcomes of the tests in which the numbers of analyst tracking are used as an intermediary variable. It can be seen that the level of analyst tracking is able to, to a certain degree, reflect the transparency of data. The coefficient of digital transformation that the analysts paid attention to was 0.0079 ($p < 0.01$), and this shows that there is a significantly positive effect. After the addition of analyst attention, the direction of the coefficient of digital transformation on E and S remains the same. Meanwhile, analyst attention itself does not show any significant impact on social responsibility. In this situation, the mediation effect does not hold. Analyst attention is not a robust mediating effect.

Table 11. Mechanism testing3

variable	(1) ln_Analyst	(2) E_Score	(3) S_Score
ln_Digital	0.0079*** (0.0017)	-0.1337*** (0.0317)	0.0455* (0.0255)
ln_Analyst		0.3699** (0.1463)	0.0058 (0.115)
controlled variable	T	T	T
Year	T	T	T
Firm	T	T	T
Observed value	50,013	50,013	50,013

Note: Clustered standard errors. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

3.8 Instrumental Variable Analysis

To deal with the endogenous issues, the study takes the approach of using the industry-wide digital mean values as instrumental variables and then proceeds to carry out the two-stage least squares (2SLS) estimation. Table 12 shows the outcomes of the instrumental variable analysis. In the process of the first-stage results, it is indicated that for the instrumental variable (industry_mean), the coefficient for digital transformation is 0.9281 ($p < 0.01$), and the F-statistic is 2876.5. This F-statistic significantly surpasses the threshold of 10. In this way, the problem of the weak instrumental variable is excluded. In the second-phase results, it has been demonstrated that the coefficient of digital transformation on environmental performance is -0.6815 ($p < 0.01$). This shows a significantly negative effect, and the absolute value of this effect is greater than that in the baseline regression. The coefficient on social responsibility is -0.0452 ($p = 0.301$), and this coefficient is not statistically significant.

These findings serve to demonstrate that in the situation where endogeneity adjustment has been carried out, the negative impact that digital transformation exerts on environmental performance becomes more clearly pronounced. In the meantime, its positive effect which it has on social responsibility fades away.

Table 12. Instrumental variable

variable	(1) stage I	(2)stage II E	(3) stage II S
instrumental variable			
industry_mean	0.9281*** (0.0173)		
endogenous variable			
ln_Digital		-0.6815*** (0.052)	-0.0452 (0.0437)
controlled variable			
Size	0.6973*** (0.0535)	2.1559*** (0.1235)	0.4082*** (0.1013)
Lev	0.0034 (0.0085)	0.0386 (0.0253)	-0.0206 (0.0223)
ROA	0.0005*** (0.0001)	0.0010*** (0.0002)	0.0001 (0.0001)
Growth	0.0000*** (0)	0.0000*** (0)	-0.0001*** (0)
BoardSize	0.0833*** (0.0235)	-0.1229* (0.0696)	0.0465 (0.0575)
IndepRatio	-0.0029 (0.0056)	-0.007 (0.0154)	-0.0052 (0.0139)
Year	T	T	T
Firm	T	T	T
Observed value	50,013	50,013	50,013
F statistics	2876.5	—	—

Note: Firm-clustered standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Instrument: industry_mean.

4 Discussion

4.1 Theoretical Explanation

The "double-edged sword" effect can be explained from both the theoretical perspective and the mechanistic perspective.

From a theoretical perspective, in the situation where the resource-based view and stakeholder theory exist, they offer a theoretical framework for this kind of finding. On one hand, in the process of following the resource-based view, enterprises are in a state where they face limited resources, and digital investments carry out an action of crowding out environmental protection investments. Digital infrastructure, by its very nature, goes through a process of exhibiting high energy consumption and carbon emissions, and as a result, it increases environmental costs. On the other hand, in the case of basing on stakeholder theory, digitalization goes through a process of enhancing information transparency, and it also goes through a process of improving com-

munication between enterprises and stakeholders such as employees and communities, and then it elevates social responsibility performance.

From a mechanistic perspective, the study carried out an examination of three mediating mechanisms, namely green innovation, financing constraints, and analyst attention. In the situation where each of these mechanisms was considered, no significant mediating effects were identified. This kind of situation suggests that the mechanism through which digital transformation has an impact on ESG may be more of a direct one rather than being realized through the above-mentioned indirect channels. The decline in environmental performance may come from the energy consumption process of digital infrastructure, the generation of e-waste, and the investment crowding-out effects. On the contrary, the enhancement of social responsibility could be directly ascribed to the situation where information transparency is improved.

4.2 Literature Comparison

The results of this study differ from those in mainstream literature [1]. Cai et al. found a significant positive correlation between digital transformation and ESG composite scores, whereas this study revealed no significant correlation. This difference can be explained by the following aspects:

The study samples differ in time span. This paper covers the period from 2007 to 2024, while Cai et al. began their research in 2012. This study additionally includes the early digital investment period from 2007 to 2011 and the latest data from 2023 to 2024.

The models differ in their design. This study employs firm fixed effects to control for individual heterogeneity, whereas Cai et al. adopt industry fixed effects. The firm fixed effects approach is more rigorous, effectively eliminating the influence of inherent firm characteristics.

The analytical levels differ. This study delves into three dimensions—E, S, and G—and finds that positive and negative effects offset each other, explaining why the total score is not statistically significant. Cai et al., focusing solely on the total score, failed to identify this structural characteristic.

4.3 Theoretical Contributions

The theoretical contributions of this research are primarily manifested in three aspects. This research is the first one to carry out a systematic examination of the heterogeneous impacts that digital transformation exerts on the E (Environmental), S (Social), and G (Governance) dimensions. In the process of doing so, it reveals the 'double-edged sword' effect of digital transformation. It breaks through the limitation of the existing research which treats ESG as a single structure. By doing this, it offers a new perspective for corporate ESG studies.

This research makes use of panel fixed-effects models and instrumental variable methods. In comparison with the Ordinary Least Squares (OLS) methods that are used in most of the existing research, this approach provides more reliable evidence. The verification of three common mediating mechanisms turned out to be invalid. This

situation suggests that in the future, research should focus on more direct mechanism pathways. For example, it could focus on the energy consumption of digital infrastructure, e-waste, and investment crowding-out effects.

4.4 Policy Proposal

Enterprises ought to take on and adopt the concept of 'green digitalization.' In the process of carrying out digital transformation initiatives, they should, at the same time, take environmental costs into consideration and give priority to eco-friendly solutions like green data centers and clean energy. Different types of enterprises should adopt strategies that are differentiated. State-owned enterprises (SOEs) should keep on playing a leading role in fulfilling social responsibility. Then, non-SOEs need to pay special attention to the environmental costs that are brought about by digitalization. Enterprises in high-pollution industries should move forward with digital transformation in a cautious manner, and they should give priority to the process of resolving traditional environmental issues.

Governments ought to carry out the action of strengthening the environmental regulation of digital infrastructure. They can do this by taking the step of incorporating high-energy-consuming facilities, for example, data centers as well as 5G base stations, into carbon emission management systems. And then, they should encourage enterprises to take the measure of adopting green electricity.

Investors ought to direct their attention towards the information of the sub-dimensions of ESG instead of simply carrying out an examination of the total score. In the process of digital transformation, it may bring about an enhancement of social responsibility. However, it may also cause harm to the environment. And the total score is not able to reflect this kind of structural disparity. Investors should make a selection of investment targets that place emphasis on either social responsibility or environmental performance according to their own preferences.

5 Conclusion

This study finds that digital transformation significantly reduces environmental performance (E) and significantly improves social responsibility (S), with no significant impact on governance performance (G). The positive and negative effects offset each other, resulting in no significant impact on the ESG total score. Heterogeneity analysis reveals that the negative environmental effect is stronger in non-state-owned enterprises, while the positive social effect is stronger in state-owned enterprises.

This study has several limitations. The digital transformation measure is based on annual report word frequency, which cannot distinguish between the "preparation phase" and "completion phase." Future research could refine the measurement using digital intangible asset data. The sample is limited to Chinese A-share listed companies, so generalization requires caution. The mediation mechanisms are not fully established, and future research could explore more direct channels.

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