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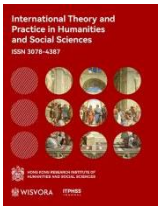

Impact of Digital Finance on Environmental, Social and Governance (ESG) Performance of Chinese Listed Firms: The Mediating Role of Corporate Digital Transformation

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Abstract

This study focuses on Chinese listed companies, aiming to explore the relationship between digital finance, corporate digital transformation, and ESG performance, and further analyze the mediating role of digital transformation in this process. Based on data from Chinese Shanghai and Shenzhen A-share listed companies between 2012 and 2022, this study uses ESG performance data published by the Huazheng ESG Rating and the digital financial index from Peking University. To empirically test how digital finance would impact corporate ESG performance, this study uses the panel data model with two-way fixed effects. This study addresses endogeneity issues by employing lagged one-period ESG data for robustness checks and replacing the core explanatory and dependent variables to ensure the robustness of the conclusions. Additionally, a heterogeneity analysis is performed based on ownership type (state-owned vs. non-state-owned) and regional location (eastern, central, western). The findings indicate that: (1) the development of digital finance significantly contributes to improving corporate ESG performance, and the conclusion remains robust even after considering endogeneity and replacing variables; (2) mechanism analysis reveals that digital transformation is an important mediating variable through which digital finance affects corporate ESG performance; (3) heterogeneity analysis shows that digital finance has a more significant effect on the ESG performance of state-owned enterprises, possibly due to their advantages in resource acquisition and policy support. Additionally, digital finance has a stronger impact on enhancing ESG performance in the central and western regions of China compared to the eastern region.

1. Introduction

With the rapid economic development of countries around the world, the conflict between economic benefits and ecological protection has intensified, and green development and

sustainable development have increasingly become the guiding principles for national(Friede et al., 2015;Weston & Nnadi, 2023;National Congress of the Communist Party of China, 2022). The report of explicitly points out that nature is the fundamental condition for human survival and development, and emphasizes the need to accelerate the green transformation of development models, deeply advance environmental pollution prevention, and actively and prudently promote carbon peaking and carbon neutrality. Against this backdrop, companies in the new era are expected not only to improve their development quality and operational efficiency but also to pay more attention to environmental protection, fulfill social responsibilities, and improve governance, striving to achieve green and sustainable development (Ren et al., 2023;Su et al., 2023). ESG performance is currently an important standard used internationally to evaluate corporate green and sustainable development, encompassing environmental, social responsibility, and corporate governance aspects. Companies' focus on ESG and their inherent ESG advantages have become new competitive strengths for the future (Dalal & Thaker, 2019;Li et al., 2024). However, according to the report of(SynTao Green Finance, 2024), the overall ESG rating of listed companies in China is relatively low, with only 5.96% of companies achieving an A rating in 2023. Moreover, the prediction from(ChinaIRN.com, 2024) shows that China's total demand for green investment will reach 139 trillion yuan to achieve the goal of carbon neutrality. However, China's green industry requires over 2 trillion yuan of investment annually, while public fiscal resources can only meet 10% to 15% of the demand for green investment. How to guide the market to increase green investment and how to balance economic, social, and ecological benefits to improve ESG performance have become pressing issues that need to be addressed.

In the wave of digitalization, using digital technology to enhance the flow of data as a productive factor and optimize resource allocation has become a key means for companies to enhance competitiveness (Guo et al., 2023;Li & Pang, 2023). According to the statistics from (China Academy of Information and Communications Technology, 2024), the scale of China's digital economy has reached to 53.9 trillion yuan in 2023 with the annual growth rate at 7.39%. This scale is expected to exceed 60 trillion yuan by 2025, making digital transformation an inevitable trend for companies. However, the digital transformation of Chinese firms is still in its early stages, and its effects are not yet significant. The survey from (Accenture, 2023) regarding China Enterprise Digital Transformation shows that only 2% of Chinese companies have launched a comprehensive reshaping strategy, becoming re-shapers. Digital transformation plays

an important role in improving operational efficiency, enhancing market competitiveness, and promoting sustainable development. Therefore, Chinese companies need to actively advance digital transformation to meet future development challenges.

By utilizing digital technology to enhance financial services' reach as well as efficiency, digital finance plays a vital role in driving digital transformation and improving ESG performance. Digital transformation requires a stable financial system and sufficient funding as a guarantee, while digital finance compensates for the serious biases of traditional finance in resource allocation, allowing financial services to overcome "time and space" constraints and significantly improve efficiency (Liu et al., 2023). This provides stable financial support for more companies, thereby facilitating digital transformation and enhancing ESG performance (Su et al., 2023;Zhao & Cai, 2023). Digital finance, as a key driver of corporate digital transformation, essentially influences Chinese companies' ESG performance.

Prior literature on digital finance, digital transformation, and ESG performance mainly focuses on the following aspects: first, the drivers of corporate ESG performance and their impacts, such as governance structure (Velte, 2016;Qian & Yang, 2023) and information infrastructure (Zhai et al., 2023;Wang & Zhang, 2024). ESG performance is believed to improve corporate investment efficiency (Bilyay-Erdogan et al., 2024), performance (Dalal & Thaker, 2019;Bruna et al., 2022), and promote environmental protection practices (Tarmuji et al., 2016;Xiong et al., 2024). Second, the role of digital finance in enhancing corporate digital transformation: although the degree of digital technology adoption varies across industries, integration between financial institutions and companies faces certain challenges . Digital finance is considered capable of reducing information asymmetry, expanding the allocation of financial resources, and better serving long-tail groups. Third, the impact of digital finance on corporate ESG performance: digital finance can effectively alleviate corporate financing constraints, promote technological innovation, and enhance corporate value (Luo, 2022;Yu & Yan, 2022). Fourth, the role of digital transformation in improving ESG performance: digital transformation helps reduce the cost of fulfilling corporate social responsibilities, enhances ESG investment capacity and governance levels, and further promotes ESG development (Lu et al., 2022;Mu et al., 2023). However, a review of the literature reveals several limitations: studies on the drivers of corporate ESG performance largely emphasise governance structure and information infrastructure, with insufficient attention given to financial factors; few studies directly examine

the relationship between digital finance and ESG performance; and the role of corporate digital transformation as a mediating variable has not received enough attention, with no research integrating digital finance, digital transformation, and ESG performance into a unified analytical framework.

Based on this, the research questions and objectives include: How and to what extent does digital finance influence corporate ESG performance? If so, whether digital transformation mediates this impact? To answer these questions, this study takes Chinese listed companies in the Shanghai and Shenzhen A-share markets from 2012 to 2022 as the research sample, examining the relationship between digital finance, corporate digital transformation, and ESG performance. The aim is to explore the role of digital finance in improving ESG performance, as well as to analyze the mediating effect of corporate digital transformation within this relationship. This study empirically tests the data through regression analysis with two-way fixed effects. In this study, the data on ESG are lagged one period in order to control for the problem of endogeneity. Further, the paper investigates heterogeneous effects of digital finance on aspects of equity nature and regional heterogeneity in terms of impacts on ESG performance.

Theoretically, this study integrates digital finance, corporate digital transformation, and ESG performance into a unified analytical framework, revealing the mechanisms by which companies can enhance ESG performance through a digital pathway. This empirical research extends the application of digital finance in the ESG field and further enriches the theoretical framework related to digital transformation and corporate sustainability. The study also delves into ownership type and regional disparities, highlighting the differentiated impacts of digital finance on corporate ESG performance across different types of companies and regions, thus providing new insights into how firms can effectively promote ESG performance under varying developmental contexts. These theoretical contributions not only address existing research gaps but also provide valuable references for future related studies.

Practically, this study provides strong decision-making references for Chinese companies on how to enhance ESG performance through digital finance and digital transformation, which holds significant practical implications for addressing sustainable development and green transformation challenges. The findings of this research can help Chinese companies find more effective paths to balance economic and ecological benefits, especially under the backdrop of

China's push for the dual carbon goals, contributing to green transformation. Furthermore, the study offers valuable policy recommendations for the Chinese government and regulatory bodies to guide companies in fulfilling social responsibilities and advancing green development, supporting the national objectives of ecological civilization and high-quality development.

2. Literature Review and Hypotheses

2.1 Digital Finance and Corporate ESG Performance

ESG performance is currently an important standard used internationally to evaluate corporate green and sustainable development, encompassing three core aspects: environmental protection, social responsibility, and corporate governance. In the process of improving ESG performance, a key challenge that companies face is a shortage of funds, especially when green technological innovation is needed. Environmental technology R&D and efficient resource utilization often require substantial capital investment(Ren et al., 2023). However, the traditional financial system has inherent biases in resource allocation, which makes it challenging for numerous small and medium-sized enterprises (SMEs), especially those focusing on green innovation, to secure sufficient funding. Digital finance, as an external financial driver for corporate development, can effectively alleviate financing constraints. Digital finance, through the use of Internet technology to expand the coverage of financial services and further exacerbate financial inclusion, provides funding support for those companies that otherwise could not be reached by traditional financial services. In light of the concept of green development or sustainable development, for example, it offers dependable financial support for firms embracing waste treatment or using other resources efficiently in product development. Compared with traditional finance, digital finance is more inclusive and efficient in services, which could eliminate funding bottlenecks and promote corporate environmental technology innovation, thus leading to an ultimate improvement in ESG performance (Ning & Zhang, 2023).

Corporate social responsibility (CSR) shall be based on a sound operating condition, which involves not only whether a company has sufficient financial resources to fulfill its social responsibilities but also its long-term sustainable development capability. However, for many companies, funding shortages and operational difficulties often prevent them from fulfilling their social responsibilities. Especially in times of increased economic uncertainty, many companies

prioritize allocating limited resources to ensure day-to-day operations rather than investing in CSR initiatives. Against this backdrop, the emergence of digital finance provides new opportunities for improving corporate operations and gaining access to funds. Digital finance, through big data analytics and artificial intelligence (AI) technology, reduces the cost of financial transactions and the uncertainty of risk assessment, enabling companies, especially SMEs, to obtain funding at a lower cost (Wang et al., 2024). As companies' operating conditions improve, their investments in social responsibilities also increase, such as improving employee welfare, contributing to community development, and supporting social welfare projects, thereby enhancing their social responsibility performance within ESG (Lu & Cheng, 2024). More importantly, the convenient financial services provided by digital finance improve the efficiency with which companies obtain funds, further promoting operational stability and growth, and providing a solid material foundation for fulfilling their social responsibilities.

Corporate governance is a key element in achieving sustainable development, and effective corporate governance not only helps enhance transparency and efficiency in internal management but also strengthens a company's competitiveness in the market. The rise of digital finance provides new impetus for changes and optimizations in corporate governance models (Mo et al., 2023). By providing digital and intelligent financial services, digital finance enables companies to achieve digitalization and informatization in product design, service processes, and internal management, thereby enhancing the scientific nature of internal decision-making and increasing the transparency of information exchange and interaction with external stakeholders. The application of digital financial tools, such as blockchain and AI, effectively helps companies enhance their corporate governance, optimizing governance structures (Mu et al., 2023;Xiang et al., 2024). For example, blockchain technology can improve the transparency of internal controls, prevent financial information fraud, and protect the rights of shareholders and stakeholders, while AI can be used for corporate risk management and internal control, enhancing governance efficiency and accuracy. Improved corporate governance is an indispensable part of ESG performance, and effective governance helps companies better fulfill environmental and social responsibilities . Therefore, digital finance, by promoting the improvement of digital management and governance levels, ultimately contributes to optimizing overall corporate ESG performance. As such, this paper proposes the first hypothesis (H1):

H1: Digital finance helps improve the ESG performance of Chinese firms.

2.2 Mediating Impact of Corporate Digital Transformation

Corporate digital transformation, as a high-level technological innovation activity, involves deep-seated changes in management models, business processes, and resource allocation, and typically requires long-term and stable financial support (Guo et al., 2023). However, in the traditional financial system, the provision of funds is often limited, especially for small and medium-sized enterprises (SMEs) and emerging companies, which, due to a lack of collateral or credit information, find it difficult to obtain adequate funding support. Therefore, the rise of digital finance provides a new source of funding and technical support for corporate digital transformation. Digital finance, relying on digital technologies such as big data and artificial intelligence (AI), not only expands the channels for financial resource allocation but also offers flexible and diversified financial service products to companies (Luo, 2022). The inclusive nature of digital finance effectively alleviates the problems of funding shortages and financing constraints faced by companies during the financing process, enabling more SMEs to access financial support, thereby promoting the process of corporate digital transformation. Additionally, digital finance, through big data analysis, helps financial institutions comprehensively understand the financial status and operational information of companies, reducing information asymmetry, and enabling companies to better plan and implement their digital transformation strategies.

Another important advantage of digital finance lies in its information provision and precise service capabilities. By leveraging big data and cloud computing technologies, digital finance can collect and process vast amounts of market information, thereby mitigating information asymmetry between financial institutions and firms, allowing financial resources to be allocated more effectively (Liu et al., 2023). It can be expected that the elite capture phenomenon in the traditional financial system, where the large companies would normally be more likely to be funded, has been greatly relieved in the context of digital finance, while SMEs face difficult access to finance due to either information opacity or lack of credit. Through digital finance, companies can obtain comprehensive and transparent financing information; in line with their fund demand and development stage, they can precisely get the most suitable financial service product (Zou, 2023). For instance, companies use the information provided by the digital finance platforms to choose different tools of financing methods, reduce funding cost, and avoid potential risks (Zhang et al., 2023). Meanwhile, it encourages the emergence of new digital business models, represented by mobile payment platforms, promoting the asking of new industries like

digital health care and online education, with more opportunities for corporate digital transformation. Digital finance has supplied new opportunities for corporate digital transformation with precisely obtained information and diversified financial services, helping companies grasp market opportunities and comprehensively enhance their ESG performance.

In promoting corporate digital transformation, digital finance not only provides financial and informational support but also has a profound impact on corporate internal management and external image. The core of corporate digital transformation is to achieve comprehensive upgrades and optimization through digital technology, thereby enhancing a company's competitiveness in the market and its capacity for sustainable development (Wu & Li, 2023). Against the backdrop of green development and the dual carbon goals becoming the themes of the new era, corporate digital transformation also assumes significant social responsibility, with digital technology playing a crucial role. First, corporate digital transformation can incorporate resource efficiency, environmental protection, and other green development concepts into top-level design, relying on digital technologies to promote green innovation in areas such as clean production and waste treatment, directly enhancing corporate environmental protection capabilities (Su et al., 2023). Second, digital transformation significantly increases operational transparency, enhancing the trust of stakeholders (such as governments and consumers) in the company, encouraging the company to pay greater attention to social responsibility, including employee welfare, community development, and environmental protection. Finally, digital transformation systematically changes market factors, resource allocation, and value creation, allowing companies to optimize internal management and governance structures by integrating digital development and governance models, thus improving digital governance capabilities. This reduces information asymmetry between companies and stakeholders, increases operational efficiency, and enhances social recognition. By lowering operational costs and increasing business efficiency, digital transformation lays a solid foundation for improving corporate ESG performance. As such, to companies, digital finance plays as a mediator to indirectly enhance ESG performance by promoting digital transformation. Therefore, the H2 is presented in this section:

H2: Digital finance plays positive impact on enhancing the ESG performance of Chinese firms by promoting digital transformation.

3. Methodology

3.1 Model Construction

The two-way fixed effects regression model (1) is employed to test H1, the impact of digital finance on the ESG performance of Chinese listed companies, referring to prior works (Zhong et al., 2023). The two-way fixed effects regression model controls for unobserved firm-specific and time-specific effects, reducing bias. By accounting for variations across firms and over time, the model provides a more accurate estimation of digital finance's impact, compared with the pooled-ordinary least square (OLS) regressions.

$$ESG_{it} = \beta_0 + \beta_1 DFCI_{it} + \beta_j \sum_j Controls_{it} + \mu_i + \theta_t + \delta_{it} \quad (1)$$

In model (1), ESG_{it} is the ESG performance for company *i* at time *t*. $DFCI_{it}$ is the digital finance level of province where the company *i* is located at time *t*. $Controls_{it}$ are controlling variables. β_0 is intercept term. β_1 and β_j are regression coefficients. μ_i is the entity fixed effect for company *i*. θ_t is the time fixed effect for time period *t*. δ_{it} is the random error.

Furthermore, the H2 is tested via the following models (2) and (3), regarding whether digital transformation mediates the impact of digital finance on ESG performance.

$$CDT_{it} = \beta_0 + \beta_1 DFCI_{it} + \beta_j \sum_j Controls_{it} + \mu_i + \theta_t + \delta_{it} \quad (2)$$

$$ESG_{it} = \gamma_0 + \gamma_1 DFCI_{it} + \gamma_2 CDT_{it} + \gamma_j \sum_j Controls_{it} + \mu_i + \theta_t + \delta_{it} \quad (3)$$

In model (2) and model (3), CDT_{it} is the degree of corporate digital transformation for company *i* at time *t*. If the coefficient β_1 in model (2) is significant, and the coefficient γ_2 in model (3) is also significant, it indicates that CDT has a significant mediating effect.

3.2 Variable Definitions

This study follows previous research and uses the Huazheng ESG rating (ESG) as the dependent variable in the baseline model. The Huazheng ESG rating is divided into 9 levels and is updated four times per year. The 9 levels of Huazheng ESG rating from lowest to highest are: C, CC, CCC, B, BB, BBB, A, AA, and AAA. In this study, numerical values from 1 to 9 are assigned to these

ratings, and a company's annual average rating is utilized to represent its ESG performance for that year, referring to (Zhong et al., 2023). The larger values of ESG indicates the companies have better ESG performance.

The independent variable of electronic finance is the Digital Finance Composite Index (DFCI), calculated referring to prior works as the provincial-level index from Peking University's Digital Finance Inclusion Index (DFII) divided by 100 (Lu et al., 2022;Guo et al., 2021). The DFII is a framework approach to measuring the inclusiveness and wide reach of digital finance, aiming to comprehensively reflect the level of inclusive service provided by digital finance to different social groups and regions. More concretely, DFII is usually measured by the breadth of digital financial coverage, namely, users and regional coverage, the depth of its usage, namely, the degree to which users make use of digital financial services, and the level of digitalization in inclusive finance, that is, the convenience, low cost, and credit that may be granted in financial services.

About the mediating variable, this paper uses text analysis and word frequency statistics to construct the index of corporate digital transformation (CDT). Annual reports have the characteristics of both retrospective summaries and forward-looking outlooks, making it meaningful and feasible to measure digital transformation through text analysis and word frequency statistics of these reports (Rha & Lee, 2022). The specific method for constructing the CDT index is as follows: first, drawing on (Wu et al., 2021), a digital dictionary is created based on five dimensions—artificial intelligence, big data, cloud computing, blockchain, and digital technology applications. Second, based on this dictionary, the Python "jieba" tool is used to perform text analysis and word frequency statistics on the txt format of annual reports. Finally, the word frequencies of each digital-related keyword for each company are summed to obtain the total digital word frequency, which is then added 1 and logarithmically transformed, and subsequently timed by 100, as the measure of CDT.

Furthermore, a number of controlling variables are selected, referring to prior works (Zhong et al., 2023), displayed in Table 1 as follows.

Table 1 Summary of variable definitions

Category	Variable	Symbol	Definition
Dependent	ESG	ESG	ESG= Huazheng ESG rating

variable	performance		
Independent variable	Digital finance	DFCI	The digital finance composite index (DFCI): DFCI= Provincial-Level Index of Peking University's Digital Finance Inclusion Index/ 100
Mediating variable	Corporate digital transformation	CDT	CDT is calculated using text analysis and word frequency statistics, referring to [39]
Controlling variables	Firm size	SIZE	SIZE= Natural logarithm of firm total assets
	Return on assets	ROA	ROA= Net profit/ Total assets
	Asset-liability ratio	ALR	ALR= Total liabilities/ Total assets
	Board independence	BOI	BOI= Number of independent directors/ Total number of board directors
	CEO duality	DUAL	DUAL= 1 if board chairman and CEO are the same person; otherwise, DUAL= 0.
	Ownership concentration	OWC	OWC= Holding percentage of the first largest shareholder
	Industry code	INC	The INC is measured using 1 to 18 representing industries from the 2012 Industry Classification by the China Securities Regulatory Commission (CSRC)

3.3 Sampling and Data Collection

This study collects the latest data of Chinese A-share listed companies on the Shanghai and Shenzhen Stock Exchanges from 2011 to 2022 as the research sample. Data on the level of digital

finance are obtained from the Peking University Digital Financial Inclusion Index (2011-2022), and the original data are sourced from two databases: CSMAR as well as Wind. Meanwhile, data of ESG rating is derived from the Huazheng ESG Rating System in China. The data on corporate digital transformation are obtained by conducting text analysis and word frequency assessments of annual reports, which are sourced from Shenzhen and Shanghai Stock Exchanges. The final sample consists of 1,184 firms with the total number of firm-year observations 14,208 (=1,184*12).

To ensure the quality and representativeness of the sample, the study excludes (1) ST &*ST companies as well as delisted firms, to eliminate the impact of financial distress and operational anomalies on the results; (2) B-share companies, to avoid the influence of accounting standards differences between Chinese domestic and foreign stock markets; (3) listed companies in the financial sector (including commercial banks, security companies and insurance companies), due to their distinct regulatory requirements and financial structure; and (4) companies with severe financial data deficiencies, to ensure data completeness and reliability. To mitigate the impact of extreme values, the micro-level continuous variables (including CDT, ROA and ALR) are subjected to a 5% Winsorization at both tails.

4. Empirical Results

4.1 Descriptive Statistics

The E-views software is applied to process data, variable descriptions are presented in Table 2. That is, ESG performance (ESG) has a mean value of 4.1621, with a range from 1.0000 to 8.0000, indicating considerable variation in ESG performance across companies. The DFCI has a mean of 2.6742, with a maximum of 4.6069 and a minimum of 0.1622, suggesting a substantial difference across companies, highlighting the diversity in digital finance levels within the sample. Similarly, CDT has a mean of 0.0874, with values ranging from 0.0038 to 0.4756, also indicating considerable variation among firms in terms of digital transformation efforts. The remaining control variables, including SIZE, ROA, ALR, BOI, DUAL, and OWC, exhibit varying means and standard deviations, reflecting the diversity in financial characteristics, corporate governance, and ownership structures among the firms.

Table 2 Descriptions to variables

	Observations	Mean	Median	Maximum	Minimum	Std. Dev.
ESG	14,208	4.1621	4.0000	8.0000	1.0000	1.1252
DFCI	14,208	2.6742	2.7206	4.6069	0.1622	1.1217
CDT	14,208	0.0874	0.0349	0.4756	0.0038	0.1236
SIZE	14,208	22.5293	22.3482	28.6067	17.8864	1.3991
ROA	14,208	0.0332	0.0323	0.1203	-0.0839	0.0468
ALR	14,208	0.4448	0.4445	0.7929	0.1175	0.1968
BOI	14,208	0.3776	0.3636	0.8000	0.1667	0.0583
DUAL	14,208	0.2494	0.0000	1.0000	0.0000	0.4327
OWC	14,208	0.3299	0.3031	0.8649	0.0184	0.1505

Note: ESG= Huazheng ESG rating, DFCI= Digital finance composite index, CDT= Corporate digital transformation degree, SIZE= Firm size, ROA= Return on assets, ALR= Asset-liability ratio, BOI= Board independence, DUAL= CEO duality, OWC= Ownership concentration

4.2 Unit Root Analysis

Based on the unit root test results reported in Table 3, this study conducts unit root tests for key variables ESG, DFCI, and CDT. Since this study uses short panel data, Fisher ADF and IPS methods are employed to test the stationarity of the variables. The Fisher ADF test results show that all variables are significant at the 0.1% level, with p-values less than 0.001. Similarly, the IPS test results indicate that all variables are significant at the 0.1% level, with p-values less than 0.001. Therefore, ESG, DFCI, and CDT are stationary series, strongly rejecting the null hypothesis of unit root existence.

Table 3 Unit root test to variables

	Fisher ADF test		IPS test	
	Statistic	p-value	Statistic	p-value
ESG	4593.48***	0.000	0.000***	0.000
DFCI	7030.17***	0.000	0.000***	0.000
CDT	2633.33***	0.000	-105.93***	0.000

Note: ESG= Huazheng ESG rating, DFCI= Digital finance composite index, CDT= Corporate digital transformation degree

*p< 0.05, **p< 0.01, ***p< 0.001

4.3 Baseline Regressions

Table 4 presents the two-way fixed-effect (FE) regression results for the impact of digital finance on ESG performance. Model (1) includes all control variables, while Model (2) adds the independent variable—Digital Finance Composite Index (DFCI). Both models are statistically significant, as indicated by the F-statistics (F = 12.340***, p < 0.001) for Model 2). Model (2) reports an R-squared of 0.533, indicating that 53.3% of the variance in ESG performance is explained by the model. The independent variable DFCI shows a positive and significant coefficient (B= 0.371***, p < 0.001), indicating that the higher degree of digital finance would bring higher level of ESG performance. Regarding the control variables, they all show significant effects on ESG performance, highlighting their importance in influencing ESG outcomes.

Table 4 Fixed-effect (FE) regression of ESG and digital finance

	Model (1)	Model (2)
DFCI		0.371***
SIZE	0.349***	0.344***
ROA	1.203***	1.234***
ALR	-1.229***	-1.223***
BOI	0.947***	0.919***
DUAL	-0.062**	-0.063**
OWC	0.409***	0.424***
INC	-0.021***	-0.021***
Constant	-3.573***	-4.460***
R-squared	0.532	0.533
F-statistics	12.322***, p< 0.001	12.340***, p< 0.001
Periods included	12	12
Cross-sections included	1,184	1,184
Total panel observations	14,208	14,208

Note: Dependent variable: ESG= Huazheng ESG rating
Independent variable: DFCI= Digital finance composite index
Controlling variables: SIZE= Firm size, ROA= Return on assets, ALR= Asset-liability ratio, BOI= Board independence, DUAL= CEO duality, OWC=

Ownership concentration, INC= Industry code
Model: Two-way fixed effects (FE)

*p< 0.05, **p<0.01, ***p< 0.001

4.4 Mediation Mechanism Test

Table 5 presents the results of the FE regression to examine the mediating effect of corporate digital transformation (CDT) on the impact of digital finance (DFCI) on ESG performance. Model (1) investigates the effect of DFCI on CDT, showing that DFCI has a positive and significant coefficient (B= 0.051***, p< 0.0001), indicating that digital finance positively affects corporate digital transformation. Model (2) includes DFCI as an independent variable for ESG performance, and Model (3) incorporates CDT alongside DFCI to examine the mediating role.

In Model (3), CDT has a significant positive effect on ESG performance (B= 0.725***, p< 0.001), while DFCI also remains significant (B= 0.334***, p< 0.001), suggesting a partial mediating effect of CDT. This implies that digital finance impacts ESG performance both directly and indirectly through corporate digital transformation. The R-squared value in Model (3) is 0.534, indicating a slightly higher explanatory power compared to Model (2), while the F-statistic (F= 12.383***, p< 0.001) confirms the overall significance of the model. Regarding control variables, they show significant effects across Model (2) and Model (3), indicating that they have notable influences on ESG performance.

Table 5 Mediating effect of corporate digital transformation (CDT)

	Model (1): Dependent Variable: CDT	Model (2): Dependent Variable: ESG	Model (3): Dependent Variable: ESG
DFCI	0.051***	0.371***	0.334***
CDT			0.725***
SIZE	0.014***	0.344***	0.334***
ROA	-0.029*	1.234***	1.255***
ALR	-0.003	-1.223***	-1.220***

BOI	-0.021	0.919***	0.934***
DUAL	0.001	-0.063**	-0.064**
OWC	-0.038***	0.424***	0.452***
INC	0.002***	-0.021***	-0.022***
Constant	-0.351***	-4.460***	-4.205***
R-squared	0.829	0.533	0.534
F-statistics	52.286***, p< 0.001	12.340***, p< 0.001	12.383***, p< 0.001
Periods included	12	12	12
Cross-sections included	1,184	1,184	1,184
Total panel observations	14,208	14,208	14,208

Note: Dependent variable: Model (1): CDT= Corporate digital transformation
Model (2) and Model (3): ESG= Huazheng ESG rating
Independent variable: DFCI= Digital finance composite index
Mediating variable: CDT= Corporate digital transformation
Controlling variables: SIZE= Firm size, ROA= Return on assets, ALR= Asset-liability ratio, BOI= Board independence, DUAL= CEO duality, OWC= Ownership concentration, INC= Industry code
Model: Two-way fixed effects (FE)

*p< 0.05, **p<0.01, ***p< 0.001

4.5 Robustness Test

4.5.1 Endogeneity Problem Check

To further examine the impact of digital finance on corporate ESG performance and address potential endogeneity issues, this section employs one-year lagged ESG performance (ESGL1) as the dependent variable in the regression analysis. Using lagged data helps reduce reverse causality issues in the impact of corporate digital finance on ESG performance. Additionally, this approach could help mitigate endogeneity bias potentially caused by omitted variables, thereby enhancing the robustness and reliability of the estimates.

Table 6 presents the fixed-effect regression results using the one-year lagged ESG performance as the dependent variable. In Model (1), digital finance (DFCI) has a significant

positive effect on the one-year lagged ESG performance (B= 0.392***, p< 0.001). In Model (2), after incorporating corporate digital transformation (CDT), DFCI remains significant (B= 0.362***, p< 0.001), while CDT also has a significant positive coefficient (B= 0.572***, p< 0.001), indicating that CDT plays a partial mediating role in the relationship between digital finance and ESG performance. These results are consistent with the previous analysis, further demonstrating the positive effect of digital finance on ESG performance, with corporate digital transformation playing an important mediating role. Regarding the control variables, most still impact ESG performance significantly.

Table 6 One-year lagged ESG as the dependent variable

	Model (1)	Model (2)
DFCI	0.392***	0.362***
CDT		0.572***
SIZE	0.403***	0.395***
ROA	0.197	0.208
ALR	-1.022***	-1.021***
BOI	0.356	0.365
DUAL	-0.066**	-0.066**
OWC	0.821***	0.842***
INC	-0.015*	-0.017*
Constant	-5.927***	-5.713***
R-squared	0.555	0.556
F-statistics	12.294***, p< 0.001	12.313***, p< 0.001
Periods included	11	11
Cross-sections included	1,184	1,184
Total panel observations	13,024	13,024

Note: Dependent variable: ESGL1= One-year lagged Huazheng ESG rating
Independent variable: DFCI= Digital finance composite index
Mediating variable: CDT= Corporate digital transformation
Controlling variables: SIZE= Firm size, ROA= Return on assets, ALR= Asset-liability ratio, BOI= Board independence, DUAL= CEO duality, OWC= Ownership concentration, INC= Industry code

Model: Two-way fixed effects (FE)
*p< 0.05, **p<0.01, ***p< 0.001

4.5.2 Variable Replacement Method

To further test the robustness of the results, this study adopts an alternative approach for the dependent variable by reclassifying the 9-points Huazheng ESG rating system into 3-points (ESG2). Specifically, the original ratings of CCC, CC, and C are reclassified as 1 point, indicating low ESG performance; BBB, BB, and B are reclassified as 2 points, indicating moderate ESG performance; and AAA, AA, and A are reclassified as 3 points, indicating high ESG performance. Regressions outcomes are reported in Table 7.

In specific, in Model (1), the DFCI has a significant positive effect on ESG2 (B= 0.114**, p< 0.01), and this effect remains significant in Model (2) after adding CDT, with DFCI having a coefficient of (B= 0.108**, p< 0.01). CDT also has a positive and significant impact on ESG2 (B= 0.210***, p < 0.001), indicating that corporate digital transformation partially mediates the relationship between digital finance and ESG performance. Thus, the positive effect of digital finance on ESG performance remains robust even when using the simplified ESG2 rating.

Table 7 Replacing ESG with ESG2 as the dependent variable

	Model (1)	Model (2)
DFCI	0.114**	0.108**
CDT		0.134*
SIZE	0.123***	0.121***
ROA	0.421***	0.425***
ALR	-0.414***	-0.414***
BOI	0.074	0.077
DUAL	-0.003	-0.003
OWC	0.205***	0.210***

INC	-0.007**	-0.007**
Constant	-1.203***	-1.156***
R-squared	0.400	0.397
F-statistics	7.120***, p< 0.001	7.120***, p<0.001
Periods included	12	12
Cross-sections included	1,184	1,184
Total panel observations	14,208	14,208

Note: Dependent variable: ESG2= 3-points classification of Huazheng ESG rating
Independent variable: DFCI= Digital finance composite index
Mediating variable: CDT= Corporate digital transformation
Controlling variables: SIZE= Firm size, ROA= Return on assets, ALR= Asset-liability ratio, BOI= Board independence, DUAL= CEO duality, OWC= Ownership concentration, INC= Industry code
Model: Two-way fixed effects (FE)

*p< 0.05, **p<0.01, ***p< 0.001

To further test the robustness of the results, an alternative approach is also adopted by replacing the explanatory variable. Specifically, digital finance (DFCI) was replaced with two alternative measures: digital finance coverage breadth (DFCB) and digital finance usage depth (DFUD), reported in Table 6. These two dimensions provide a more detailed perspective on digital finance, with DFCB capturing the extent of digital finance services coverage across different regions and DFUD reflecting the intensity or depth of digital finance utilization by individuals and businesses. The regression coefficients of DFCB and DFUD remain significant and positive, seen in Table 8. Thus, both the coverage and depth aspects of digital finance contribute significantly to improving ESG performance, with corporate digital transformation acting as an important channel through which digital finance exerts its influence.

Table 8 Replacing DFCI with DFCB and DFUD as the independent variables

	Model (1)	Model (2)	Model (3)	Model (4)
DFCB	0.349**	0.310**		
	(0.111)	(0.111)		
DFUD			0.206***	0.189***
			(0.050)	(0.050)
CDT		0.737***		0.731***
		(0.132)		(0.132)
SIZE	0.346***	0.336***	0.345***	0.335***

	(0.017)	(0.017)	(0.017)	(0.017)
ROA	1.190***	1.215***	1.245***	1.266***
	(0.209)	(0.209)	(0.209)	(0.209)
ALR	-1.218***	-1.216***	-1.232***	-1.229***
	(0.077)	(0.076)	(0.076)	(0.076)
BOI	0.942***	0.955***	0.919***	0.933***
	(0.186)	(0.186)	(0.186)	(0.186)
DUAL	-0.062**	-0.063**	-0.063**	-0.064**
	(0.024)	(0.024)	(0.024)	(0.024)
OWC	0.405***	0.434***	0.432***	0.459***
	(0.114)	(0.114)	(0.114)	(0.114)
INC	-0.021***	-0.022***	-0.020***	-0.022***
	(0.006)	(0.006)	(0.006)	(0.006)
Constant	-4.388***	-4.128***	-4.049***	-3.843***
	(0.463)	(0.465)	(0.400)	(0.402)
R-squared	0.533	0.534	0.533	0.534
F-statistics	12.328***, p< 0.001	12.373***, p< 0.001	12.341***, p< 0.001	12.385***, p< 0.001
Periods included	12	12	12	12
Cross-sections included	1184	1184	1184	1184
Total panel observations	14208	14208	14208	14208

Note: Dependent variable: ESG= Huazheng ESG rating
Independent variable: DFCB= Digital finance coverage breath, DFUD= Digital finance usage depth
Mediating variable: CDT= Corporate digital transformation
Controlling variables: SIZE= Firm size, ROA= Return on assets, ALR= Asset-liability ratio, BOI= Board independence, DUAL= CEO duality, OWC= Ownership concentration, INC= Industry code
Model: Two-way fixed effects (FE)

*p< 0.05, **p<0.01, ***p< 0.001

4.6 Heterogeneity Test

4.6.1 Equity Nature Difference

Different ownership structures may lead to varying impacts of digital finance on ESG performance. Therefore, this study further divides the sample into state-owned enterprises (NOE = 1) and non-state-owned enterprises (NOE = 0) to examine the heterogeneous effects of equity nature. An interaction term between ownership type and digital finance (DFCI*NOE) is

constructed for the regression analysis to assess the differential impact of digital finance across different equity natures (Table 9).

In Model (2) in Table 9, which includes the equity nature dummy variable (NOE) and the interaction term (DFCI*NOE), the interaction term is found to be positive and significant (B= 0.122***, p< 0.0001), indicating that the effect of digital finance on ESG performance is stronger for Chinese SOEs compared to non-SOEs. The results suggest that while digital finance enhances ESG performance across all firms, SOEs benefit more significantly from digital finance initiatives.

Table 9 Heterogeneity between SOEs and non-SOEs

	Model (1)	Model (2)
DFCI	0.371***	0.352***
	(0.092)	(0.092)
NOE	0.008	-0.356***
	(0.050)	(0.064)
DFCI*NOE		0.122***
		(0.013)
SIZE	0.344***	0.355***
	(0.017)	(0.017)
ROA	1.235***	1.135***
	(0.209)	(0.209)
ALR	-1.224***	-1.104***
	(0.077)	(0.078)
BOI	0.920***	0.869***
	(0.186)	(0.185)
DUAL	-0.062**	-0.060*
	(0.024)	(0.024)
OWC	0.425***	0.258*
	(0.114)	(0.115)
INC	-0.021***	-0.018**
	(0.006)	(0.006)
Constant	-4.465***	-4.622***
	(0.443)	(0.442)
R-squared	0.533	0.536
F-statistics	12.329***, p< 0.001	12.464***, p< 0.001
Periods included	12	12
Cross-sections included	1,184	1,184
Total panel observations	14,208	14,208

Note: Dependent variable: ESG= Huazheng ESG rating
Independent variable: DFCI= Digital finance composite index; NOE= Nature of equity: NOE= 1 if the firm is state-owned; otherwise, NOE= 0; DFCI*NOE= The interaction term of DFCI and NOE

Mediating variable: CDT= Corporate digital transformation
Controlling variables: SIZE= Firm size, ROA= Return on assets, ALR= Asset-liability ratio, BOI= Board independence, DUAL= CEO duality, OWC= Ownership concentration, INC= Industry code
Model: Two-way fixed effects (FE)

*p< 0.05, **p<0.01, ***p< 0.001

4.6.2 Regional Difference

There are significant heterogeneities in digital finance levels, corporate ESG performance, and development stages across different regions in China. The digital finance may also exhibit notable regional heterogeneity in impacting corporate ESG performance. Therefore, this study divides the 31 provinces of mainland China into Eastern[1] (REG = 1) and non-Eastern (Central and Western, REG = 0) regions to conduct regression analysis and examine the regional heterogeneity effect. An interaction term between regional differences and digital finance (DFCI*REG) is accordingly constructed for the regression (Table 10).

In Model (2) in Table 10, the interaction term between DFCI and REG (DFCI*REG) is negative and significant (B= -0.037*, p< 0.05), suggesting that the positive effect of digital finance on ESG performance is weaker in the Eastern region compared to non-Eastern (Central and Western) regions. Overall, these results suggest that while digital finance positively impacts ESG performance across all regions, this effect is less pronounced in the more developed Eastern region compared to the non-Eastern regions of China.

Table 10 Heterogeneity in Eastern region and non-Eastern region

	Model (1)	Model (2)
DFCI	0.256**	0.401***
	(0.099)	(0.116)
REG	0.380**	0.428***
	(0.122)	(0.124)
DFCI*REG		-0.037*
		(0.016)
SIZE	0.344***	0.346***
	(0.017)	(0.017)

[1] Provinces in Eastern region of China include: Beijing, Hebei, Liaoning, Tianjin, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong and Hainan.

ROA	1.217*** (0.209)	1.205*** (0.209)
ALR	-1.213*** (0.077)	-1.206*** (0.077)
BOI	0.924*** (0.186)	0.931*** (0.186)
DUAL	-0.062** (0.024)	-0.061** (0.024)
OWC	0.419*** (0.114)	0.400*** (0.114)
INC	-0.021*** (0.006)	-0.020*** (0.006)
Constant	-4.412*** (0.442)	-4.798** (0.471)
R-squared	0.533	0.533
F-statistics	12.346***, p< 0.001	12.346***, p< 0.001
Periods included	12	12
Cross-sections included	1,184	1,184
Total panel observations	14,208	14,208

Note: Dependent variable: ESG= Huazheng ESG rating
Independent variable: DFCI= Digital finance composite index; REG= Region: REG= 1 if the firm is located in Eastern region; otherwise, REG= 0 if the firm is located in Central or Western region; DFCI*REG= The interaction term of DFCI and REG
Mediating variable: CDT= Corporate digital transformation
Controlling variables: SIZE= Firm size, ROA= Return on assets, ALR= Asset-liability ratio, BOI= Board independence, DUAL= CEO duality, OWC= Ownership concentration, INC= Industry code
Model: Two-way fixed effects (FE)

*p< 0.05, **p<0.01, ***p< 0.001

5 Discussions and Conclusions

5.1 Discussions

First, based on the findings of this study, it is evident that the development of digital finance helps improve corporate ESG performance. This conclusion remains valid even after using lagged one-period ESG data and re-running the regression by replacing the core dependent and independent variables, indicating the robustness in the promoting role of digital finance to improve ESG performance of firms. This result is consistent with many previous studies. In this

context, digital finance has provided more development opportunities for companies by expanding financing channels and enhancing the efficiency of financial services. However, some researchers also stress that, in the current Chinese market, there is a difference in the depth and effectiveness of digital finance application among firms. Because of inadequate digital infrastructure or without enough understanding and capabilities to use digital finance tools, some companies are unable to make full use of advantages brought by digital finance. In addition, while digital finance development can offer inclusive financial services, in real life, whether a firm can enjoy the merits brought about by digital finance is decided by the level of digitalization and the financial strength of the firm. The results of this study reveal that, on the whole, digital finance does promote the ESG performance of Chinese firms. How to ensure that different types of companies can equally benefit from such an improvement remains an issue that needs further attention.

Second, this research finds that digital transformation is a mediating variable in the relationship between digital finance and corporate ESG performance. Digital finance can promote better ESG performance by possibly driving corporate digital transformation(Guo et al., 2023). Fundamentally, digital transformation is a high-level technological innovation that features the radical change of corporate management, business process, and redistribution of resources. Through the process of digital transformation, operational efficiency and market competitiveness will be enhanced, hence further optimization of ESG performance. As one example, the findings of this study imply that in environmental protection, applying digital technology enables Chinese companies to obtain higher resource utilization efficiency and better pollution control. It is also helpful to improve transparency and management levels in social responsibility and corporate governance. However, the digital transformation level among Chinese firms may be different since some firms face such issues as poor digital infrastructure, limited funds, too little technical talent, and so on, which makes digital transformation relatively slower and affects the improvement in overall ESG performance. The essence of digital transformation lies not only in the use of new technologies but also implies significant changes in corporate strategy, management models, and organizational structure-long-term investments that require long-term resources. Thus, even if digital finance can positively influence Chinese firms' ESG performance through facilitating digital transformation, the comprehensiveness of such an influence would depend on corporate resources and circumstances. The results of this study further underpin the

fact that successful implementation and effectiveness of digital transformation depend highly on the firms' digital foundation and adaptability; this is also one of the key challenges faced by digital finance in the promotion of ESG performance.

Furthermore, based on heterogeneity analysis by equity nature, this study concludes that the role of digital finance differs among firms with different equity natures. The result implies that improvement in ESG performance brought about by digital finance is stronger in Chinese SOEs than in their non-SOEs counterparts. The works of and also have the same results. However, this result is contradictory to, which found that digital finance has a more significant influence on the ESG rating of Chinese non-SOEs. The reason for such a difference may be that SOEs have comparative advantages in access to funds and resources. First, the government always supports SOEs very well, which results in access to financing channels and policy benefits easily, giving them more comparative advantages in digital finance development. The particular financing advantage of SOEs enables they are fully utilizing of the funds and technical means provided by digital finance, which in turn enhances environmental protection, social responsibility, and corporate governance. In addition, SOEs also face higher demands in policy direction, especially in the current emphasis on green development and sustainability by the government. Therefore, leading by example, it is expected that SOEs will be at the vanguard in terms of social responsibilities. Thus, supported by digital finance, in terms of funding support and technical tools, the ESG performance of SOEs could be enhanced more effectively [30]. In addition, most of the time, compared with non-SOEs, SOEs are more transparent in information disclosure and regular in management. That provides them with better opportunities to apply digital finance toward a more efficient allocation of resources and optimizing business operations, which can further improve ESG performance. At the same time, the findings also suggest that digital finance still leaves much to be desired in terms of inclusiveness and equity for companies of different ownership types. Being inclusive in nature, digital finance can make the difference, especially in the case of SOEs, while for non-SOEs-mostly SMEs-their lack of resources and policy support may not display in reality the benefits of digital finance.

Moreover, heterogeneity analysis also points out that regional differences exist in the function of digital finance among companies in the east and those in the central and western areas of China. This study's results prove that digital finance has been instrumental in enhancing ESG performance at companies in the central and western regions. It implies that this result of the

paper coincides with and, but is in contrast to that of [30], which finds that the greater effect of digital finance on ESG ratings of Chinese firms located in the eastern region. This may be because firms in these regions receive less support from traditional financial services. The traditional financial system often favors the economically developed eastern region of China in terms of resource allocation. In other regions, e.g. central and western, however, it would be more difficult for firms to obtain financing. Accordingly, this would lead to the widespread of funding shortages. The inclusive characteristics of digital finance bridge this gap by expanding the coverage of financial services through internet technology, enabling companies in the central and western regions to better access funding, particularly in areas related to green development and sustainability. The growth of digital finance offers firms in central and western regions of China more accessible financing options while also facilitating their digital transformation through technological advancements, thereby making more significant progress in environmental protection, social responsibility, and corporate governance(Ning & Zhang, 2023). Therefore, the spread of digital finance has a more positive impact on the ESG performance of companies in the central and western regions, suggesting that, under digital finance, the sustainable development capacity of firms in these regions has significantly improved. However, these regional differences also reflect an imbalance in the promotion and application of digital finance in different regions. Although the eastern region is more economically developed, the marginal effect of digital finance shows relatively weak marginal effect on promoting these firms' ESG performance. This may be partially due to the fact that companies in the eastern region have already received substantial support from the traditional financial system, resulting in a less significant additional effect from digital finance compared to companies in the central and western regions(Mo et al., 2023). Therefore, how to further reduce the gap between the eastern and central/western regions and ensure that digital finance can fully play its role in different areas remains an important issue for policymakers.

This study empirically examines the impact of digital finance on corporate ESG performance and the mediating role of digital transformation. However, it inevitably has research limitations. First, the study sample is limited to Chinese Shanghai and Shenzhen A-share listed companies from 2012 to 2022, which may restrict the generalizability of the conclusions to some extent. Future research could consider expanding the sample scope, such as including Hong Kong-listed companies or companies from other economies, to test the external validity of the conclusions.

Second, this study did not further distinguish the heterogeneity effects of industry and firm size, which may overlook the differences in ESG performance and digital finance application among different types of companies. Future research could conduct more detailed analyses of the relationship between digital finance and ESG performance in different industries and company sizes to gain deeper insights. Moreover, this study primarily uses a two-way fixed-effect regression method for causal analysis. Although this approach can alleviate endogeneity issues to some extent, future research could consider using more complex methods such as instrumental variable techniques or experimental designs to further enhance the credibility of causal inferences. Lastly, the relationship between digital finance and ESG performance is dynamic, but this study only considers lagged one-period data. Future research could systematically examine the long-term effects of digital finance on corporate ESG performance by introducing dynamic panel models and other methods.

5.2 Practical Implications

First, the Chinese government should continue to increase investment in digital financial infrastructure, particularly by promoting the widespread use of digital financial platforms and tools to ensure that all types of firms can leverage digital finance to enhance their ESG performance. Government and related institutions can encourage companies to actively participate in the development of digital finance through policy incentives and financial support, especially focusing on those firms that are relatively weak in building digital infrastructure. In addition, corporate management should increase efforts to learn and apply digital financial tools, enhancing the internal acceptance and usage capability of digital finance, in order to fully utilize the funding support and information services provided by digital finance to improve corporate ESG performance, especially in areas such as environmental protection, social responsibility fulfillment, and corporate governance.

Second, Chinese firms should place great importance on the role of digital transformation in promoting sustainable development. In practice, corporate management should formulate clear digital transformation strategies, integrating digital technology into corporate management, production, and services to improve operational efficiency, resource utilization efficiency, and information transparency, thereby enhancing ESG performance. Specifically, companies should embrace digital technology in enhancing environmental management and pollution control, social

responsibility, and corporate governance scientifically. Meanwhile, relevant policies and regulations at the corresponding level of governments should be developed to support the movement of digitization for companies. The Chinese government, for instance, could give out company-specific funding support to overcome certain financial bottlenecks in the process of digital transformation and provide needed training and technical guidance to strengthen their digital competencies. In addition, for such companies under big pressure in digital transformation-such as shortage of money and technical talents-the government should give more exactly focused assistance in order to make firms improve ESG performance by upgrading digitally.

Third, taking full consideration of the differentiation of corporate equity types and regions would be particularly conducive to the comprehensive improvement of ESG performance via digital finance. The findings of this paper suggest that digital finance has a more significant positive influence on the ESG performance improvement in SOEs; however, so far, it has not substantially improved ESG performance in non-SOEs, especially for resource-poor companies. Policymakers should, therefore, pay even greater attention to the differences in access to resources, supporting policies, and financing channels of various types of firms. More inclusive and supportive policies are particularly needed to enable non-SOEs and SMEs to take full advantage of digital finance in their pursuit of ESG performance improvement. Besides, this study also finds that digital finance promotes ESG performance in the central and western regions more than in the eastern parts of China, suggesting that in practice, more support should be given to central and western regions so as to further reduce disparities in regional development. Governments and related institutions can increase investment in building digital financial infrastructure in the central and western regions, and provide more training and financial support to local firms to help them better leverage digital finance for ESG development. By adopting more balanced development strategies and inclusive policy support, it is possible to ensure that different companies and regions can fairly benefit from the development of digital finance, thereby achieving a comprehensive improvement in ESG performance across the country.

5.2 Concluding Remarks

Based on data from Chinese Shanghai and Shenzhen A-share listed companies from 2012 to 2022, this study used ESG performance data published by Huazheng ESG Rating and the digital

financial inclusion index from Peking University to empirically examine the relationship between digital finance, digital transformation, and corporate ESG performance. The research findings show: Firstly, the development of digital finance significantly contributes to improving corporate ESG performance, and even after using lagged one-period ESG data and re-running the regression by replacing core dependent and independent variables, the conclusions remain robust, indicating that digital finance has strong robustness in enhancing corporate ESG performance. Secondly, mechanism analysis shows that digital transformation is a mediating variable through which digital finance affects corporate ESG performance, as digital finance promotes corporate digital transformation, thereby further enhancing ESG performance. This mechanism validates the crucial role of digital transformation as a bridge between digital finance and ESG performance. Heterogeneity analysis further reveals that, compared with non-SOEs, digital finance has a stronger impact on the ESG performance of SOEs, which may be related to the advantages of SOEs in resource acquisition and policy support. In addition, digital finance has a more significant effect on the ESG performance of companies in the central and western regions of China, while the improvement in eastern region companies is relatively small, indicating that digital finance plays a more pronounced role in areas with less resource support.

This study comprehensively examines the role of digital finance in enhancing ESG performance through digital transformation, thereby advancing the theoretical understanding of corporate sustainability in the digital age. The research findings provide practical insights for policymakers and businesses seeking to leverage digital finance and digital transformation to achieve sustainable development goals, emphasizing its pivotal importance in shaping the future of corporate environmental, social, and governance practices.

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