

## Article

# Digital Finance Promotes Corporate ESG Performance: Evidence from China

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**Abstract:** Whether and how digital finance can promote corporate environmental, social, and governance (ESG) development has become an important issue. Based on panel data from listed companies in the Shanghai and Shenzhen stock markets from 2011 to 2017, this paper investigates whether and how digital finance can promote the ESG performance of Chinese companies. The empirical results indicate that digital finance not only promotes the ESG performance of Chinese companies but also indirectly facilitates it by alleviating their financing constraints. Channel tests reveal that digital finance predominantly facilitates corporate ESG development through the promotion of social performance and corporate governance performance, but it does not contribute to corporate ESG development by promoting corporate environmental performance. Further research finds that digital finance more strongly promotes ESG in enterprises in the eastern region, state-owned enterprises, small enterprises, and polluting enterprises. Finally, this article puts forward some policy recommendations for high-quality economic development in China, such as driving “ESG financial innovation” to make full use of the enabling role of digital finance in corporate ESG development, effectively bringing enterprises’ attention to environmental performance development and guiding digital finance to promote ESG development in the western region and in non-state-owned enterprises.

**Keywords:** digital finance; financing constraints; corporate ESG; corporate operations



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## 1. Introduction

Business operation has long been dominated by the principle of “profit maximization,” which results in a range of negative incidents that prioritize economic interests and harm ecology, as well as violate social morality [1,2]. This recognition of unprincipled, profit-oriented goals can lead to a serious social misunderstanding of the rational goals of economic activity, which run counter to the objective of attaining high-quality economic development [3]. It is, therefore, crucial to practically promote diversified business strategies that prioritize the high-quality development of enterprises and more.

As China shifts toward a new economic growth model and implements the “dual carbon” strategy, there has been a growing awareness of the importance of environmental, social, and governance (ESG) responsibilities. The China Securities Regulatory Commission revised the Code of Governance for Listed Companies in 2018, mandating that listed companies integrate ecological protection into their corporate development strategies, focus on public welfare, and standardize their corporate information disclosure systems. This initiative aims to promote the stable and healthy development of China’s capital market. The ESG concept provides listed companies with a comprehensive development framework on greening, social promotion, and corporate governance, which are crucial for improving corporate performance and corporate value [4,5]. Moreover, it perfectly aligns with the fundamental requirements for China’s economy to achieve sustainable and high-quality development. Meanwhile, constructing ESG projects requires long-term and stable financial support. A good financial environment and abundant funding are necessary

for enterprises to carry out ESG activities. Unfortunately, China's financial market has monopolistic structural characteristics, resulting in a relative concentration of loan objects on large government projects, and there are high barriers to entering into the national financial markets and a lack of regional financing platforms in China [6]. Thus, how to refine the financial market mechanism, increase the availability of financial services, and guide the ESG development of enterprises are important issues to be considered in the current economic development of China.

In recent years, China's economy has accelerated its digital transformation. The digital economy has become the new driving force of China's economic development. With the significant opportunity of booming technologies such as artificial intelligence, big data, and cloud computing, finance has also strengthened its organic integration with emerging technologies, and consequently, a new model of inclusive finance—digital finance—has emerged [7]. Digital finance refers to a novel approach that combines digital technology with traditional financial institutions and Internet companies to facilitate financial operations. It encompasses various concepts, including e-finance and fintech [8]. The Financial Technology Development Plan (2022–2025), issued by the People's Bank of China, mainly delineates the task of advancing the digital transformation of financial institutions as well as establishing a sound modern financial system adapted to the development of the digital economy, which aims to enable finance to contribute to fostering the new development paradigm. First, digital finance can optimize financial business processes and innovate financial products by using advanced technologies such as 5G and cloud computing [9,10]. Second, with its digital characteristics, digital finance enhances the transparency of financial market information and strengthens the connections between various financial entities. This, in turn, reduces the problem of information asymmetry to some extent [11]. Finally, with its inclusive advantages, digital finance can expand the boundaries of financial services, enrich the participants in the financial market, and provide financing opportunities for those in need of funds at different levels [12,13]. All of the above mechanisms can help alleviate corporate financing constraints, but whether digital finance can promote corporate ESG development after alleviating corporate financing constraints needs to be further studied.

Due to the late emergence of the ESG concept in China, there has been limited research on the comprehensive impact of digital finance on Chinese corporate ESG performance. Nevertheless, existing literature provides several studies on each aspect of digital finance for environmental development, social responsibility, and corporate governance. Regarding environmental development, Tang et al. concluded that digital finance development significantly promotes green technology innovation and that increasing the breadth of digital finance coverage and digitization could significantly promote green technology innovation [14]. Xue et al. investigated the relationship between digital finance and carbon emission reduction based on data from 278 cities and found that digital finance can mitigate regional carbon emissions [15]. Razzaq and Yang investigated the relationship between inclusive digital finance and the level of green growth and revealed that digital finance significantly drives green growth [16]. Lyu et al. found that digital finance development significantly increases green total factor productivity [17]. Muhammad et al. researched the relationship between the fintech industry and environmental efficiency across 23 EU countries, and their empirical results showed that the fintech industry can improve environmental efficiency [18]. Croutzet et al. investigated the influence of fintech development on renewable energy consumption in Organization for Economic Cooperation and Development (OECD) countries, and their empirical results showed that fintech development can boost renewable energy use [19]. Elheddad et al. found that e-finance can reduce CO<sub>2</sub> emissions in OECD countries and leads to a lower pollution rate [20]. Regarding social responsibility, Wen et al. studied the relationship between digital finance and banks' social responsibility, finding that the impact of digital finance on banks changes from a "competitive effect" to a "technological spillover effect" and the impact on their social responsibility is first inhibited and then promoted [21]. Alkhazaleh and Haddad found that

financial technology services have a significant positive effect on customer satisfaction in Jordanian banks [22]. Ayse et al. investigated the interrelationship between fintech, financial inclusion, and income inequality for a panel of 140 countries, and their empirical results revealed that fintech reduces income inequality indirectly through its effects on financial inclusion [23]. Henri et al. found that the use of mobile money services can enhance the monetary welfare of vulnerable people in Cameroon [24]. Regarding corporate governance, scholars have focused on digital finance in corporate innovation, investment efficiency, and corporate governance. Zhang et al. found that digital finance can significantly improve corporate innovation levels [25]. Huang et al. argued that digital finance development can increase corporate investment efficiency by reducing financing constraints and stimulating corporate innovation [26]. Chen found that digital finance development is conducive to the implementation of mergers and acquisitions and can promote them by improving corporate governance [27]. Al-Matari et al. found that fintech can enhance firm performance in the Saudi Arabian Financial Sector [28]. Arena et al. demonstrated that the fintech business model can promote the financial performance of Italian banks [29]. Akhtar and Nosheen found that fintech and bank M&As can promote operating performance, liquidity, and financial leverage of banks in developed countries, but it reduces the bank's market performance in the long run [30]. Abbasi et al. investigated the relationship between fintech and Small and Medium Enterprises (SMEs) efficiency from 22 OECD countries, and their empirical results revealed that fintech positively affects corporate efficiency [31].

In summary, the existing literature mainly concentrates on the impact of digital finance on individual aspects of the environment (E), social responsibility (S), and corporate governance (G), and simultaneously, most of them focus on the impact of digital finance at the macro level or individual factors at the micro level. However, these studies may not comprehensively measure the contribution of digital finance in motivating companies to focus on environmental development, fulfilling their social responsibility, or optimizing their governance systems. With the steady progress of China's financial market and the increasing level of financial digitalization, the resource allocation problems in the traditional financial market are gradually being addressed. As a consequence, financial markets can provide technical and financial support to enterprises to improve their ESG levels. From these, several pertinent questions arise: Can digital finance contribute to corporate ESG development? What are the characteristics of different categories of companies in this effect? Can digital finance contribute to corporate ESG development after alleviating corporate financing constraints? Which aspects of ESG will corporate decision-makers mainly invest in? All these questions deserve in-depth investigation.

Therefore, this paper focuses on the question of whether and how digital finance can contribute to corporate ESG development and empirically investigates the mechanisms underlying the influence of digital finance development on the advancement of corporate ESG performance by using the Digital Finance Index (DFI) published by Peking University from 2011 to 2017. The possible contributions of our article are as follows. First, our study empirically demonstrates that digital finance not only promotes the corporate ESG performance of Chinese companies but also indirectly facilitates it by alleviating their financing constraints. Our study clarifies the specific mechanisms of digital finance on corporate ESG development. Second, through an in-depth analysis of the impact of digital finance on the three dimensions of corporate ESG performance, our study finds that digital finance contributes to corporate ESG development mainly by enhancing corporate social responsibility and corporate governance performance, while most companies are more negligent about environmental responsibility, which may be a reflection of their shortsighted and self-interested behavior. Third, considering that different enterprises have different production features and business objectives, our study classifies enterprises according to different criteria and finds that digital finance more strongly promotes ESG in enterprises in the eastern region, state-owned enterprises (SOEs), small enterprises, and polluting enterprises.

The structure of the article is as follows. Section 2 deduces the research hypotheses, Section 3 introduces the methodology and data, Section 4 analyzes the regression results, Section 5 further researches, and Section 6 summarizes the study and puts forward relevant policy recommendations.

## 2. Research Hypotheses

### 2.1. Digital Finance Promotes Corporate ESG Performance

Digital finance, with its digital advantages, helps companies to drive digital transformation, reduce the cost of reforming ESG strategies, and promote technology upgrades, empowering companies to improve ESG levels. First, digital finance can facilitate corporate digital transformation [32], which, in turn, can lead to improvements in ESG performance. This transformation can help enterprises reduce energy intensity, lower regional carbon emissions [33], and promote green technology innovation [34]. It also drives the service-oriented transformation of enterprises, improves service awareness, and boosts corporate social responsibility performance [35]. Additionally, digital platforms can increase companies' transparency and enhance the quality of companies' internal control [36].

Second, digital finance can reduce the cost of implementing ESG strategies, make projects more feasible, and allay operators' concerns about cost and decision effectiveness. Numerous social welfare projects enter the public arena through digital financial platforms, which enable enterprises to expeditiously discern and seize ESG projects that align with their distinct characteristics. This process decreases the possibility of missed opportunities due to information asymmetry, thereby improving matching efficacy and lowering the costs of entry into ESG programs. The application of digital tools digitizes and makes controllable the management process of social responsibility projects, which helps enterprises precisely position the demands of their target group, quantify social responsibility objectives, and predict the effect of fulfilling social responsibility [37]. This effect can greatly improve management efficiency over social responsibility, reduce management costs, improve the efficiency of ESG reform, and ultimately promote corporate ESG development.

Third, digital finance can facilitate the enhancement of enterprise production technology and promote enterprise innovation [38], thereby supporting enterprises in their pursuit of improved technological capabilities and business performance. After enterprises meet their economic interests, they are more willing to make contributions to ESG responsibilities and fulfill social obligations. In view of this, we propose the following hypothesis:

**Hypothesis 1 (H1).** *Digital finance promotes corporate ESG performance.*

### 2.2. Digital Finance Promotes Corporate ESG Performance by Alleviating Its Financial Constraints

According to a report by the World Bank, some nonfinancial listed companies in China consider financing constraints the primary obstacle to their corporate development [39]. According to the China Business Operators Questionnaire Tracking Survey Report released by the Development Research Center of the State Council, Chinese firms generally consider financing constraints a major constraint to their development [40]. When firms face high financing constraints and lack sufficient internal capital, managers may prioritize investment activities that better align with immediate economic interests, thereby neglecting ESG construction.

Digital finance, with its inclusive and digital characteristics, can alleviate corporate financing constraints through two potential mechanisms. First, digital finance can cut the cost of financing for firms, alleviating their financing constraints. China's underdeveloped securities market and inadequate capital markets aggravate information asymmetry, which leads to higher search costs, bargain costs, contract costs, and supervision costs of SMEs' transaction finances [41]. By employing data crawling technology and other methods, digital finance can create a green channel for information exchange among financial institutions, which increases the transparency of enterprise information, mitigates adverse selection in the financial market, and reduces matching costs between financing parties. It also leads to

more accurate lending by financial institutions, lowering opportunity costs and the time costs of obtaining funds for enterprises that have ESG investment intentions. Meanwhile, higher levels of information transparency and extensive information channels increase the cost and difficulty of falsifying the accounting and financial information of enterprises, which effectively inhibits irregular operations of executives for private interests, improves the level of enterprises' real project surplus management, and indirectly optimizes their financing decisions, thus realizing the reduction of financing costs [42].

Second, digital finance drives the innovation of financing tools in the financial market. It integrates information and analyzes current corporate needs through digital technology, deriving a variety of credit intermediaries that provide diversified and customized financing services for enterprises. The "competitive crowding-out effect" of digital finance in the nonbanking sector on the banking sector is gradually shifting to the "catfish effect," which drives the digital transformation of banks and enables financial product innovation, thus providing better quality financing services for enterprises, broadening financing channels, and alleviating corporate financing constraints [21]. Digital finance compensates for the shortage and mismatch of financing services in traditional financial markets and improves the general environment of the financial market, providing solid financial backing for corporate ESG constructions. Therefore, by means of the aforementioned mechanisms, digital finance can effectively alleviate the financing constraints faced by enterprises, allowing them to circumvent the dual challenges of inadequate internal financing and external funding rejections. Consequently, this improves enterprises' pursuits of ESG objectives. In view of this, we propose the following hypothesis:

**Hypothesis 2 (H2).** *Digital finance can indirectly promote ESG development by alleviating corporate financing constraints.*

### *2.3. Channel Tests: Through Which Part of ESG Does Digital Finance Primarily Improve Corporate ESG Performance?*

The concept of corporate ESG is composed of three fundamental components: environmental, social, and governance responsibility. Improving environmental responsibility performance, social responsibility performance, and corporate governance performance are three avenues through which companies can propel their ESG development. ESG represents the inclusiveness of value interests, and a key requirement of it is that firms are enabled to generate economic gains while also creating positive externalities that benefit society as a whole [43]. However, when practicing the ESG concept, managers tend to consider the relationship between economic benefits and sunk costs. They will take stock of the situation and select ESG strategies that meet the needs of corporate development and enhance corporate value.

Regarding social responsibility, there are two aspects to consider. First, based on stakeholder theory, actively fulfilling social responsibility can strengthen the relationship between an enterprise and its stakeholders, which can broaden financing channels as well as contribute to corporate innovation and corporate value [44]. Second, while fulfilling social responsibility may have externalities, the wide scope of social responsibility can bring multiple benefits to enterprises from different stakeholders. Actively fulfilling responsibility to consumers can help build a positive reputation, increase consumer trust, and attract customers [45,46]. Additionally, fulfilling responsibility to employees enhances companies' competitiveness in the labor market, attracting talented employees and, ultimately, enhancing corporate value [47].

Regarding governance responsibility, there are two points, as follows. First, high levels of corporate governance can effectively coordinate all stakeholders and ensure maximum protection of their interests, thereby motivating stakeholders to contribute more resources toward the long-term growth of the company [48]. As a result, corporate value can be enhanced. Second, corporate governance plays a crucial role in the development of companies. Sound corporate governance promotes the improvement of corporate



performance and investment efficiency [4], ultimately helping companies to achieve their profit goals.

With regard to environmental responsibility, scholars have put forward different perspectives. One view is that investing in factors such as the environment, which have strong externalities, may cause additional costs for the business, waste resources, and weaken corporate competitiveness, thus negatively affecting shareholders’ interests and diminishing corporate value [49,50]. Another view is that being active in environmental responsibility conveys positive signals to society and establishes an excellent reputation for companies, which can confer competitive advantages and enhance corporate value [51,52]. However, in China, the still imperfect environmental protection and regulatory systems may lead to negligence from managers toward environmental responsibility. The lack of scientific and effective environmental protection incentives may lead to the still strong externality of corporate fulfillment of environmental responsibility, which has little effect on the enhancement of corporate value. Therefore, rational managers may not prioritize their corporate strategy for improving corporate environmental performance. As a consequence, they will refer to the principle of maximizing corporate value, and when using digital finance to improve corporate ESG performance, they may prioritize boosting corporate ESG through improving social responsibility and corporate governance performance because these two have stronger value contributions to the company. Digital finance primarily boosts corporate ESG performance by improving social (S) and governance (G) performance, not by environmental (E) performance. In view of this, we propose the following hypothesis:

**Hypothesis 3 (H3).** *Digital finance mainly promotes ESG development by improving corporate social and governance performance; its promotion effect on corporate environmental responsibility is not significant.*

To illustrate our study more clearly, a diagram of the research framework is shown in Figure 1.

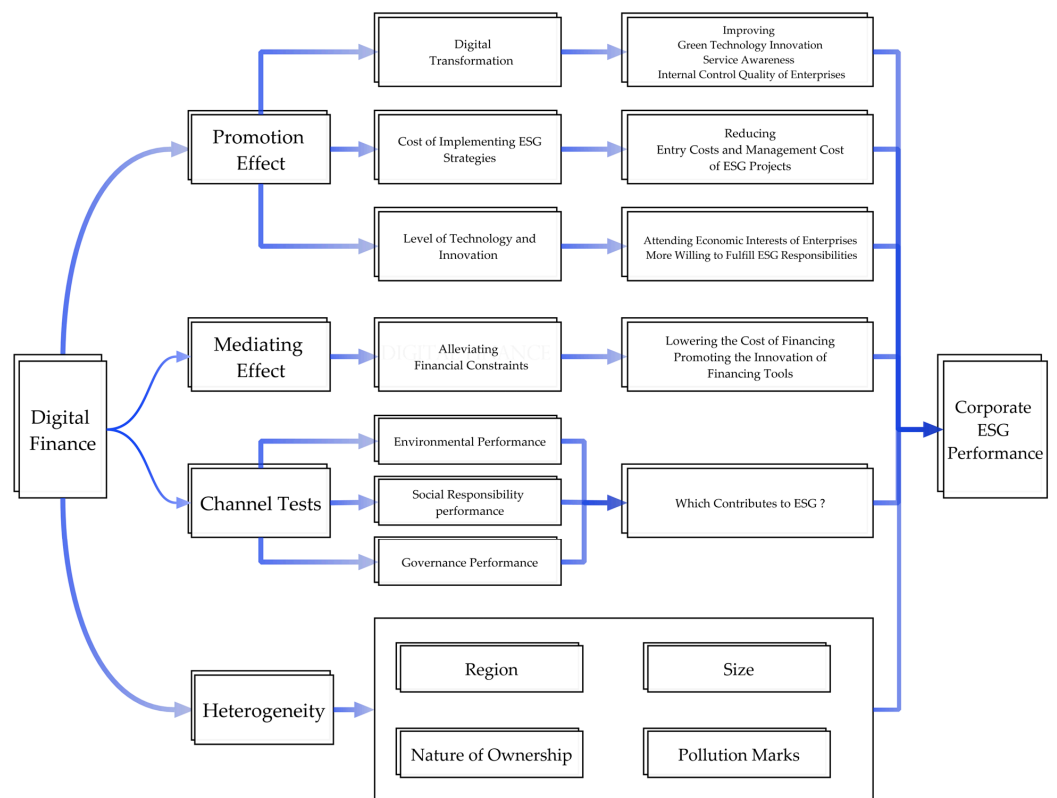


Figure 1. Research Framework.

### 3. Methodology and Data

#### 3.1. Data and Samples

In this paper, we used the A-share listed enterprises in the Shanghai and Shenzhen stock markets from 2011 to 2017 as the research sample. Referring to the research of Tang et al. [14], the data were processed as follows: (a) financial and real estate enterprises were excluded; (b) \*ST, ST companies, and IPO companies in the sample period were excluded; (c) samples with five or more years of continuous data were retained; (d) variables below 1% and above 99% were tailored. This paper obtained 9730 observations. Digital finance data were obtained from the Digital Financial Inclusion Index released by the Digital Finance Research Center of Peking University. Corporate ESG data were obtained from the Social Responsibility Report of Listed Companies released by Hexun and the ESG ratings published by Huazheng. Financing constraints, enterprise age, firm size, board size, corporate leverage ratio, financial expense ratio, management expense ratio, and profitability were taken from the Wind database. Growth, percentage of independent directors, capital intensity, and Tobin's Q (TobinQ) were obtained from the CSMAR database (see Table 1).

**Table 1.** Main Variables.

Variable	Variable Definitions	Symbols	Source
Dependent Variable	Corporate ESG performance	ESG_index	Hexun's Social Responsibility Report for Listed Companies
		ESG	ESG ratings published by Huazheng
	Environmental performance	E_index	Secondary Index of Hexun's Social Responsibility Report for Listed Companies
	Social performance	S_index	Secondary Index of Hexun's Social Responsibility Report for Listed Companies
Independent Variable	Governance performance	G_index	Secondary Index of Hexun's Social Responsibility Report for Listed Companies
	Digital Finance Aggregate Index	DFI	Peking University DFI
Intermediary Variables	Financing Constraints	WW	WW Index
		dfc	Interest Expense/Total Liabilities
Control variables	Firm Year	Age	Year of Sample–Year of Listing
	Firm Size	Size	Ln (Enterprise's Total Assets)
	Growth	Growth	The Growth Rate of the Enterprise's Annual Operating Income
	Profitability	LnEBIT	Ln (EBIT)
	Board Size	Board	Ln (Number of Board Directors)
	Percentage of Independent Directors	Indr	Number of Independent Directors/ Number of Board Directors
	Capital Intensity	Capital	Total Assets/Annual Revenue
	Leverage	Lev	Total Liabilities/Total Assets
	Financial Expense Ratio	Fin	Financial Expenses/Revenue
	Administrative Expense Ratio	mf	Administrative Expenses/Operating Revenue

#### 3.2. Variables

##### 3.2.1. Dependent Variable: Corporate ESG Performance (ESG\_Index)

The evaluation scores from the Social Responsibility Report of Listed Companies published by Hexun.com was used to measure the ESG performance of enterprises. First, the data for constructing the evaluation scores were derived from the social responsibility reports and annual reports released by the official websites of enterprises in the Shanghai and Shenzhen Stock Exchanges. Second, in order to comprehensively demonstrate the ESG performance of enterprises, the professional evaluation system of the report examines five aspects: environmental responsibility, employee responsibility, supplier–customer and consumer rights responsibility, social responsibility, and shareholder responsibility. The Hexun corporation also established secondary and tertiary indicators, providing a comprehensive evaluation of ESG, comprised of 13 s-tier indicators and 37 third-tier

indicators, and the data comprehensively reflects the actual situation of enterprises' ESG construction. Finally, the scores have been widely used by scholars in various studies, and the authority of the data is widely certified. This paper also adopts the ESG ratings published by Huazheng for robustness testing.

To analyze the impact of digital finance on the three dimensions of corporate ESG, this paper uses the secondary indicators of the Social Responsibility Report of Listed Companies published by Hexun to indicate the performance of enterprises in environmental responsibility, social responsibility, and corporate governance. Among them, the performance of corporate environmental responsibility (E\_index) is indicated by the corporate environmental responsibility index. The performance of social responsibility (S\_index) is indicated by the summation of the employee responsibility, supplier–customer and consumer rights responsibility, and social responsibility indices. The performance of corporate governance (G\_index) is indicated by the shareholder responsibility index.

### 3.2.2. Independent Variable: DFI

The DFI was selected from the Inclusive Finance Index published by Peking University. The index system is constructed from three dimensions of financial services: breadth of coverage, depth of use, and level of digitalization [7]. It comprises a total of 11 secondary dimensions and 33 specific third indicators. Regarding the breadth of coverage, the account coverage rate is chosen as one of its sub-dimensions. The metrics used include the number of Alipay accounts per 10,000 people, the proportion of Alipay users with bank cards, and the average number of bank cards linked to each Alipay account. In terms of depth of use, it is measured from six perspectives: payment, money fund, credit, insurance, investment, and credit investigation. Specific indicators in this dimension include the number of payments per capita, the number of Yu'eobao purchases per capita, the number of loans per capita, the number of insurance policies per capita, the average investment amount per capita, and the number of credit investigations by natural persons per capita. As for the level of digitalization, the index measures from four perspectives: mobility, affordability, credit, and convenience. Specific indicators in this dimension include the proportion of mobile payments, the average loan interest rate for individuals, the proportion of Ant Check Later payments, and the proportion of QR code payments by users, among others. The index has been widely used by scholars in studying digital financial finance in the China region and has proven to be highly applicable. These data were used to indicate the degree of provincial digital finance development. In this paper, we also chose city-level DFI for robustness testing. The digital financial index was divided by 100 in this paper for measurement convenience.

### 3.2.3. Intermediary Variables: Financing Constraints

- WW index (WW): The financial constraint index constructed by Whited and Wu was used to measure the degree of financing distress faced by enterprises [53]. The larger the WW index, the greater the financing distress faced by enterprises.
- The ratio of annual interest expense to total debt (dfc): To verify that the results of this paper have not been affected by the selection of the financing constraint index, this paper referred to the research of Yu et al. [54]. The ratio of annual interest expense to total debt (dfc) was calculated as another proxy variable for corporate financing constraints.

### 3.2.4. Control Variables

- Referring to previous literature and our own investigation, we used the following control variables in our models:
- Firm year (Age): This paper uses the sample year minus the year the firm went public.
- Firm size (Size): This paper uses the natural logarithm of the firm's total assets.
- Growth (Growth): This paper uses the growth rate of the firm's operating revenue in the corresponding year.



- Profitability (LnEBIT): This paper uses the natural logarithm of the firm's year-end Earnings Before Interest and Tax (EBIT).
- Board size (Board): This paper uses the logarithm of the number of board members.
- Percentage of independent directors (Indr): This paper uses the ratio of the number of independent directors to the total number of directors.
- Capital intensity (Capital): This paper uses the ratio of total assets to annual revenue.
- Corporate leverage ratio (Lev): This paper uses the ratio of total liabilities to total assets at the end of the period.
- Financial expense ratio (Fin): This paper uses the ratio of the enterprise's current financial expense to operating revenue.
- Administrative expense ratio (mf): This paper uses the ratio of the enterprise's current administrative expense to operating revenue.

### 3.3. Model

In order to verify whether there is a positive relationship between digital finance and enterprises' ESG development and the mediating effect of financing constraints, this paper established the following empirical research framework.

$$\text{ESG\_index}_{i,t} = \alpha_0 + \alpha_1 \text{DFI}_{i,j,t} + \alpha_2 \text{Control}_{i,t} + u + v + \varepsilon_{i,t} \quad (1)$$

$$\text{WW}_{i,t} = \beta_0 + \beta_1 \text{DFI}_{i,j,t} + \beta_2 \text{Control}_{i,t} + u + v + \delta_{i,t} \quad (2)$$

$$\text{ESG\_index}_{i,t} = \gamma_0 + \gamma_1 \text{DFI}_{i,j,t} + \gamma_2 \text{WW}_{i,t} + \gamma_3 \text{Control}_{i,t} + u + v + \mu_{i,t} \quad (3)$$

Equation (1) is the benchmark model, and Equations (2) and (3) are mediating effect models constructed with reference to the research of Wen and Ye [55]. Among them,  $\text{ESG\_index}_{i,t}$  represents the ESG performance of enterprise  $i$  in year  $t$ ;  $\text{DFI}_{i,j,t}$  represents the degree of digital finance development of enterprise  $i$  in the  $j$  province in year  $t$ ;  $\text{WW}_{i,t}$  represents the financing constraint of enterprise  $i$  in year  $t$ ;  $u$  is the year fixed effect;  $v$  is the industry fixed effect;  $\text{Control}_{i,t}$  is the control vector;  $\varepsilon_{i,t}$ ,  $\delta_{i,t}$ , and  $\mu_{i,t}$  are the random error terms of Equations (1)–(3), respectively. In this paper, clustering standard errors are used. We included industry fixed effects and refrained from firm fixed effects in our analysis due to the relatively constrained variability of our dataset across a limited number of sample years. Thus, we validated our results with year-by-year cross-sectional regressions. Given the space constraints of the article, we have chosen not to provide an exhaustive account of the results in this paper. We are happy to provide the reader with access to the validating results upon request.

## 4. Results and Discussions

### 4.1. Descriptive Analysis

Table 2 presents the descriptive results of the sample companies. The ESG performance of the listed companies, as measured by the  $\text{ESG\_index}$ , exhibits a mean and median of 26.630 and 21.340, respectively, and a standard deviation of 19.610. This indicates that there are substantial variations in the ESG performance of individual listed companies. Similarly, the DFI demonstrates a mean and median of 1.850 and 2.015, respectively, with a standard deviation of 0.772. These figures suggest that the level of digital finance development differs significantly across provinces. Additionally, the financing constraints index,  $\text{WW}$ , exhibits a mean and median of  $-1.021$  and a standard deviation of 0.075, revealing that the financing constraints encountered by different enterprises vary. Table 3 exhibits the correlation coefficients between the variables.

**Table 2.** Descriptive Statistical Results.

Variable	N	Mean	p50	Sd	Min	Max
ESG_index	9730	26.630	21.340	19.610	−3.140	76.970
ESG	9730	3.995	4.000	1.047	1.000	6.000
DFI	9730	1.850	2.015	0.772	0.249	3.299
WW	9730	−1.021	−1.021	0.075	−1.239	−0.849
dfc	9730	0.024	0.023	0.015	0.000	0.067
Age	9730	11.960	12.000	6.075	1.000	24.000
Size	9730	22.380	22.220	1.277	19.850	26.180
Growth	9730	17.330	9.339	46.490	−50.190	319.600
LnEBIT	9730	12.740	18.790	14.200	−20.810	23.270
Board	9730	2.175	2.197	0.198	1.609	2.708
Indr	9730	37.160	33.330	5.325	33.330	57.140
Capital	9730	2.312	1.771	1.880	0.363	11.980
Lev	9730	0.487	0.487	0.200	0.083	0.959
Fin	9730	2.528	1.490	4.084	−3.946	24.780
mf	9730	9.187	7.655	7.045	0.820	42.900

#### 4.2. Empirical Results: Digital Finance Enhances Corporate ESG Performance

The regression results regarding the promotion effect of digital finance on corporate ESG performance are shown in Table 4. Model (1) in Table 4 is the baseline regression without the control variables. The results indicate that digital finance positively affects corporate ESG performance and is statistically significant at the level of 1%. Model (2) is the regression including control variables. The result still shows that the DFI coefficient is significantly positive at the 1% level, indicating that digital finance empowers corporate ESG development. Digital finance can contribute to corporate ESG development by enhancing corporate digitalization and reducing the reform cost of implementing ESG decisions. Accordingly, hypothesis H1 has been verified.

#### 4.3. Empirical Results: Digital Finance Enhances Corporate ESG Performance by Alleviating Its Financial Constraints

Further, the research explored the mechanism through which digital finance affects the level of corporate ESG development. Digital finance has the characteristics of universality and openness, which can reduce the financing constraints faced by enterprises. Therefore, this paper used the alleviation of financing constraints to investigate whether digital finance contributes to corporate ESG development by alleviating corporate financing constraints. The regression results are shown in Models (3) to (6) in Table 4. Model (3) shows the relationship between digital finance and financing constraints. It can be seen that the DFI coefficient is significantly negative at the 1% level, indicating that the level of digital finance development is negatively related to the financing constraints faced by enterprises. Model (4) tests the mediating effect of financing constraints in the promotion of corporate ESG performance by digital finance. The empirical result shows that digital finance positively affects corporate ESG performance and is statistically significant at the level of 5%. The financing constraints are negatively related to corporate ESG performance and are statistically significant at the level of 1%, indicating that digital finance can promote corporate ESG development indirectly by alleviating the financing constraints of enterprises. Comparing the regression coefficients of digital finance in Models (2) and (4) shows that the effect of digital finance on corporate ESG is significantly lower after the inclusion of the mediating variable, indicating that financing constraints play a partially mediating role in the promotion of corporate ESG performance by digital finance.

**Table 3.** Correlation coefficient.

	ESG_Index	DFI	Age	Size	Growth	LnEBIT	Board	Indr	Capital	Lev	Fin	mf
ESG_index	1											
DFI	−0.122 ***	1										
Age	−0.013	0.269 ***	1									
Size	0.319 ***	0.228 ***	0.218 ***	1								
Growth	0.036 ***	−0.0120	−0.033 ***	0.043 ***	1							
LnEBIT	0.328 ***	0.0150	−0.110 ***	0.238 ***	0.183 ***	1						
Board	0.122 ***	−0.074 ***	0.049 ***	0.245 ***	−0.021 **	0.048 ***	1					
Indr	0.00800	0.035 ***	−0.00700	0.045 ***	−0.019 *	−0.023 **	−0.440 ***	1				
Capital	−0.070 ***	0.077 ***	0.067 ***	0.0120	−0.061 ***	−0.156 ***	−0.0120	0.026 ***	1			
Lev	−0.076 ***	−0.036 ***	0.272 ***	0.369 ***	0.00200	−0.120 ***	0.105 ***	0.0160	−0.078 ***	1		
Fin	−0.115 ***	−0.0100	0.160 ***	0.112 ***	−0.074 ***	−0.167 ***	0.066 ***	0.00100	0.571 ***	0.401 ***	1	
mf	−0.150 ***	0.065 ***	−0.0160	−0.348 ***	−0.104 ***	−0.310 ***	−0.104 ***	0.047 ***	0.495 ***	−0.216 ***	0.173 ***	1

Note: \*\*\*, \*\*, and \* indicate significance at the 1%, 5%, and 10% levels, respectively.

**Table 4.** Main Regression and Mediation Tests.

	(1)	(2)	(3)	(4)	(5)	(6)
Variable	ESG_Index	ESG_Index	WW	ESG_Index	dfc	ESG_Index
DFI	8.816 *** (1.466)	3.465 *** (1.260)	−0.008 *** (0.002)	2.631 ** (1.238)	−0.002 * (0.001)	3.309 *** (1.256)
WW				−99.719 *** (7.319)		
dfc						−95.128 *** (22.089)
Age		0.219 *** (0.055)	0.000 *** (0.000)	0.250 *** (0.054)	0.000 (0.000)	0.221 *** (0.055)
Size		6.198 *** (0.274)	−0.050 *** (0.000)	1.215 *** (0.449)	−0.001 *** (0.000)	6.123 *** (0.271)
Growth		−0.006 * (0.003)	−0.000 *** (0.000)	−0.048 *** (0.005)	−0.000 *** (0.000)	−0.007 ** (0.003)
LnEBIT		0.307 *** (0.018)	−0.001 *** (0.000)	0.230 *** (0.018)	−0.000 *** (0.000)	0.301 *** (0.018)
Board		2.280 (1.749)	−0.000 (0.002)	2.246 (1.710)	−0.002 * (0.001)	2.086 (1.748)
Indr		0.071 (0.060)	0.000 (0.000)	0.078 (0.058)	0.000 (0.000)	0.073 (0.060)
Capital		−0.612 *** (0.197)	0.001 ** (0.000)	−0.536 *** (0.192)	−0.002 *** (0.000)	−0.843 *** (0.200)
Lev		−19.205 *** (1.813)	0.040 *** (0.003)	−15.241 *** (1.783)	−0.007 *** (0.002)	−19.843 *** (1.807)
Fin		−0.118 (0.095)	0.000 ** (0.000)	−0.085 (0.091)	0.003 *** (0.000)	0.156 (0.111)
mf		0.187 *** (0.048)	−0.000 (0.000)	0.176 *** (0.047)	−0.000 *** (0.000)	0.161 *** (0.048)
Cons	10.316 *** (2.729)	−123.157 *** (6.936)	0.103 *** (0.011)	−112.881 *** (6.810)	0.053 *** (0.005)	−118.104 *** (6.984)
Time effect	YES	YES	YES	YES	YES	YES
Industry effect	YES	YES	YES	YES	YES	YES
N	9730	9730	9730	9730	9730	9730
Adj.R <sup>2</sup>	0.095	0.305	0.863	0.324	0.434	0.308

Note: \*\*\*, \*\*, and \* indicate significance at the 1%, 5%, and 10% levels, respectively.

In order to ensure that the findings of this paper have not been affected by the selection of the financing constraint index, the research methodology employed by Yu et al. was adopted [54]. The ratio of annual interest expense to total liabilities of firms (dfc) was used as an additional proxy variable for corporate financing constraints. The empirical results are shown in Models (5) and (6) in Table 4. Model (5) indicates that digital finance can alleviate corporate financing constraints and is statistically significant at the level of 10%. Model (6) shows that the DFI coefficients are significantly positive at the 1% level, and the dfc coefficients are significantly negative at the 1% level, which proves that the results are robust. Consequently, hypothesis H2 is verified.

#### 4.4. Channel Tests

To investigate the channels through which digital finance promotes corporate ESG development, this paper replaces the corporate ESG performance (ESG\_index) in Equations (1) and (3) with corporate environmental responsibility performance (E\_index), social responsibility performance (S\_index), and governance performance (G\_index). The empirical results are shown in Models (1) to (6) in Table 5. Models (1), (3), and (5) show that digital finance promotes corporate environmental, social responsibility, and governance performance, with the environmental dimension failing the statistical significance test of 10%. Simultaneously, the social responsibility and corporate governance dimensions

both pass the statistical significance test of 1%. This indicates that digital finance mainly promotes corporate ESG development by promoting social responsibility and governance performance, and its promotion effect for corporate environmental responsibility is not significant. Models (2), (4), and (6) show the regression results after adding the mediating financing constraints variable. Empirical results of Model (4) show that digital finance can promote social responsibility performance and is statistically significant at the level of 5%. Financing constraints are negatively related to social responsibility performance, being statistically significant at the level of 1%. Empirical results of Model (6) show that digital finance positively affects corporate governance performance, financing constraints are negatively related to corporate ESG performance, and both pass the statistical significance test of 1%. The results in Table 5 demonstrate that digital finance can promote the social responsibility and governance performance of corporations by alleviating their financing constraints, but it cannot improve their environmental performance.

Table 5. Channel Tests.

	(1)	(2)	(3)	(4)	(5)	(6)
Variable	E_Index	E_Index	S_Index	S_Index	G_Index	G_Index
DFI	0.060 (0.437)	0.024 (0.438)	1.901 *** (0.737)	1.715 ** (0.738)	1.463 *** (0.350)	0.850 *** (0.292)
WW		−4.334 * (2.356)		−22.227 *** (4.265)		−73.195 *** (2.510)
Age	0.040 ** (0.019)	0.041 ** (0.019)	0.182 *** (0.032)	0.189 *** (0.032)	−0.005 (0.016)	0.018 (0.013)
Size	1.769 *** (0.100)	1.552 *** (0.154)	2.894 *** (0.158)	1.783 *** (0.261)	1.537 *** (0.087)	−2.121 *** (0.148)
Growth	−0.004 *** (0.001)	−0.006 *** (0.002)	−0.006 *** (0.002)	−0.016 *** (0.003)	0.005 *** (0.001)	−0.026 *** (0.001)
LnEBIT	0.007 (0.006)	0.004 (0.006)	0.090 *** (0.011)	0.073 *** (0.011)	0.208 *** (0.006)	0.151 *** (0.005)
Board	0.639 (0.621)	0.637 (0.621)	1.203 (1.022)	1.196 (1.017)	0.358 (0.449)	0.333 (0.378)
Indr	0.026 (0.021)	0.026 (0.021)	0.067 * (0.035)	0.068 ** (0.035)	−0.024 (0.016)	−0.018 (0.013)
Capital	−0.189 *** (0.067)	−0.186 *** (0.067)	−0.376 *** (0.118)	−0.359 *** (0.118)	−0.049 (0.066)	0.007 (0.056)
Lev	−2.505 *** (0.607)	−2.333 *** (0.613)	−5.082 *** (1.051)	−4.198 *** (1.058)	−11.547 *** (0.563)	−8.637 *** (0.480)
Fin	0.027 (0.033)	0.029 (0.032)	−0.056 (0.054)	−0.049 (0.053)	−0.092 *** (0.031)	−0.068 *** (0.025)
mf	0.045 *** (0.016)	0.045 *** (0.016)	0.116 *** (0.030)	0.114 *** (0.030)	0.026 (0.016)	0.018 (0.013)
Cons	−38.319 *** (2.486)	−37.872 *** (2.499)	−63.496 *** (3.917)	−61.205 *** (3.922)	−21.024 *** (2.191)	−13.481 *** (1.879)
Time effect	YES	YES	YES	YES	YES	YES
Industry effect	YES	YES	YES	YES	YES	YES
N	9730	9730	9730	9730	9730	9730
Adj.R <sup>2</sup>	0.180	0.180	0.217	0.221	0.518	0.619

Note: \*\*\*, \*\*, and \* indicate significance at the 1%, 5%, and 10% levels, respectively.

To investigate why digital finance promotes ESG performance primarily through corporate social responsibility performance and corporate governance performance, the study employed corporate Tobin's Q value (TobinQ) as a proxy variable to gauge corporate value [56]. TobinQ is defined as the ratio of a company's market value to its total assets, which reflects the relationship between a company's market value and its replacement cost. By examining the relationship between corporate ESG performance (ESG\_index) and corporate value (TobinQ) and subsequently assessing the individual influence of each ESG dimension on corporate value, this paper sought to provide further insight into this



relationship. When examining the impact of the three ESG dimensions on enterprise value, all three dimensions were used as explanatory variables to prevent inaccurate results caused by omitted factors. The relevant equations are as follows.

$$\text{TobinQ}_{i,t} = \theta_0 + \theta_1 \text{ESG\_index}_{i,t} + \theta_2 \text{Control}_{i,t} + u + v + \tau_{i,t} \quad (4)$$

$$\text{TobinQ}_{i,t} = \varphi_0 + \varphi_1 \text{E\_index}_{i,t} + \varphi_2 \text{S\_index}_{i,t} + \varphi_3 \text{G\_index}_{i,t} + \varphi_4 \text{Control}_{i,t} + u + v + \vartheta_{i,t} \quad (5)$$

Among them,  $\text{ESG\_index}_{i,t}$  represents the ESG performance of enterprise  $i$  in year  $t$ ;  $\text{TobinQ}_{i,t}$  represents the value of enterprise  $i$  in year  $t$ ;  $\text{E\_index}_{i,t}$ ,  $\text{S\_index}_{i,t}$ , and  $\text{G\_index}_{i,t}$ , respectively, represent the environmental, social, and governance performance of enterprise  $i$  in year  $t$ ;  $u$  is the year fixed effect;  $v$  is the industry fixed effect;  $\text{Control}_{i,t}$  is the control vector; and  $\tau_{i,t}$  and  $\vartheta_{i,t}$  are the random error terms of Equations (4) and (5), respectively.

The empirical regression results are shown in Table 6. Model (1) is the result of the regression between  $\text{ESG\_index}$  and  $\text{TobinQ}$ . The results demonstrate that corporate ESG performance facilitates corporate value, and it passes the statistical significance test at the 1% level. Model (2) is the regression researching the impact of the three ESG dimensions on firm value. The coefficients of social responsibility performance ( $\text{S\_index}$ ) and corporate governance performance ( $\text{G\_index}$ ) are significantly positive, indicating that companies can improve their corporate value by enhancing their social responsibility performance and corporate governance performance. However, the contribution of environmental responsibility to corporate value fails to pass the statistical significance test of 10%, indicating that the performance of enterprises' environmental responsibility cannot significantly enhance corporate value. These findings indicate that digital finance can alleviate financing constraints with the application of the internet, big data, blockchain, and other technologies; provide financial guarantees for enterprises to fulfill their social responsibility; and enhance the level of corporate social responsibility. At the same time, digital finance can also drive corporate innovation and investment efficiency, assisting enterprises in optimizing business decisions and improving corporate governance. However, after alleviating financing constraints through digital finance, managers may choose not to promote an environmental responsibility performance that contributed less to corporate value due to the externality and the "self-interest" of enterprises. Hence, hypothesis H3 is verified.

#### 4.5. Robustness Tests

##### 4.5.1. Replacing the Dependent Variable

To make sure that the conclusion of this paper has not been affected by the selection of the ESG index, the ESG rating published by the Huazheng Company has been selected as another proxy variable of the ESG performance of listed companies for robustness testing. The rating takes into account information disclosure and the characteristics of companies in China, giving the evaluated enterprises a nine-grade rating of "AAA-CCC". In this paper, the nine ratings are assigned one to nine scores for regression analysis. The empirical results are shown in Model (1) of Table 7, indicating that digital finance can positively affect the ESG performance of enterprises and pass the statistical significance test of 10%.

##### 4.5.2. Replacement of Independent Variable

In this paper, the city-level DFI index is used as the independent variable in place of the provincial DFI index. The empirical results are shown in Model (2) of Table 7. It shows that the coefficients of  $\text{DFI\_city}$  are significantly positive at the levels of 10%, indicating that digital finance can positively affect the ESG performance of enterprises.

**Table 6.** Empirical Results of ESG Performance and Enterprise Value of Companies.

Variable	(1)	(2)
	TobinQ	TobinQ
ESG_index	0.007 *** (0.001)	
E_index		0.002 (0.004)
S_index		0.006 ** (0.003)
G_index		0.025 *** (0.004)
Age	0.017 *** (0.004)	0.018 *** (0.004)
Size	−0.461 *** (0.024)	−0.476 *** (0.025)
Growth	0.001 *** (0.000)	0.001 ** (0.000)
LnEBIT	−0.002 (0.001)	−0.005 *** (0.001)
Board	0.109 (0.093)	0.111 (0.094)
Indr	0.011 *** (0.003)	0.012 *** (0.003)
Capital	−0.070 *** (0.015)	−0.070 *** (0.015)
Lev	0.041 (0.152)	0.234 (0.156)
Fin	−0.004 (0.006)	−0.002 (0.006)
mf	0.042 *** (0.005)	0.042 *** (0.005)
Cons	11.033 *** (0.491)	11.095 *** (0.494)
Time effect	YES	YES
Industry effect	YES	YES
N	9379	9379
Adj.R <sup>2</sup>	0.403	0.407

Note: \*\*\* and \*\* indicate significance at the 1% and 5% levels, respectively.

#### 4.5.3. Exclusion of Partial Data

The Chinese stock market experienced two rounds of precipitous declines from June to August 2015. During this period, the Shanghai Securities Composite Index fell by more than 45%. The total market capitalization of the Shanghai and Shenzhen stock markets evaporated by approximately RMB 33 trillion. The stock market turmoil could lead listed companies into operational difficulties and affect their ESG performance. Therefore, considering the impact of the 2015 stock market crash on the results of this research, data from 2015 has been excluded from the regression analysis, and the empirical results are shown in Model (3) of Table 7. Second, in order to avoid the impact of special advantages on the research results, the data of municipalities directly under the central government (Beijing, Tianjin, Shanghai, and Chongqing) have been excluded from the regression analysis, and the empirical results are shown in Model (4) of Table 7. Both sets of empirical results demonstrate that after excluding the data from the stock market crash and the municipalities directly under the central government, digital finance still has a significant positive relationship with corporate ESG performance and passes the statistical significance tests of 1% and 5%, respectively, which indicates that the findings of this paper have strong robustness.

Table 7. Robustness Tests.

	(1)	(2)	(3)	(4)
Variable	ESG	ESG_Index	ESG_Index	ESG_Index
DFI	0.148 * (0.076)		4.512 *** (1.563)	4.259 ** (1.681)
DFI_city		1.252 * (0.730)		
Age	−0.013 *** (0.003)	0.198 *** (0.055)	0.220 *** (0.068)	0.198 *** (0.065)
Size	0.323 *** (0.017)	6.320 *** (0.267)	7.562 *** (0.327)	6.794 *** (0.340)
Growth	−0.002 *** (0.000)	−0.007 ** (0.003)	0.000 (0.005)	−0.005 (0.004)
LnEBIT	0.006 *** (0.001)	0.307 *** (0.018)	0.300 *** (0.024)	0.297 *** (0.020)
Board	0.074 (0.094)	1.452 (1.758)	3.455 (2.162)	2.886 (2.009)
Indr	0.016 *** (0.003)	0.043 (0.061)	0.125 (0.076)	0.065 (0.067)
Capital	−0.026 ** (0.013)	−0.700 *** (0.197)	−0.592 ** (0.269)	−0.720 *** (0.214)
Lev	−1.126 *** (0.108)	−20.082 *** (1.837)	−21.277 *** (2.342)	−19.816 *** (1.999)
Fin	−0.007 (0.005)	−0.092 (0.096)	−0.067 (0.123)	−0.188 * (0.102)
mf	0.001 (0.003)	0.193 *** (0.049)	0.195 *** (0.061)	0.250 *** (0.057)
Cons	−3.528 *** (0.424)	−118.040 *** (6.834)	−153.249 *** (7.996)	−138.428 *** (9.040)
Time effect	YES	YES	YES	YES
Industry effect	YES	YES	YES	YES
N	9730	9442	5687	7950
Adj.R <sup>2</sup>	0.203	0.306	0.329	0.302

Note: \*\*\*, \*\*, and \* indicate significance at the 1%, 5%, and 10% levels, respectively.

#### 4.5.4. Endogeneity Analysis

Considering the possible endogeneity between digital finance and corporate ESG, this study employed the instrumental variable approach to address it. Referring to the research methodology used by Lin and Xiao [57], the lagged one-period DFI and cell phone penetration rate (the number of cell phones per 100 people) were used as the instrumental variables for the regression analysis, respectively. The lagged one-period DFI was selected as an instrumental variable because of the possible reverse causality between digital finance and the ESG level of enterprises. Cell phone penetration was selected as an instrumental variable for the following reasons. First, the advent of Alipay and the subsequent rise of WeChat Pay in 2013 significantly altered the landscape of the mobile payment market in China. Since then, the two pivotal channels have profoundly affected the preexisting conventional bank card payment methods. The transition in payment methodologies has fostered the growth of financial technology. Therefore, the speedy development of digital finance cannot be separated from the popularity of cell phones. Second, cell phone penetration is not correlated with corporate ESG level, which satisfies the requirement of exogeneity of instrumental variables. The endogeneity test results are shown in Table 8, demonstrating that the promotion effect of digital finance on enterprise ESG level still holds at the 1% significance level. There is no overidentification constraint and weak instrumental variables for the lagged one-period DFI (DFI\_before1) and mobile phone penetration (tele), which proves the rationality of the instrumental variables selected in this paper.

**Table 8.** Endogeneity Analysis.

Variable	IV-2sls (DFI_before1)		IV-2sls (Tele)	
	Stage 1	Stage 2	Stage 1	Stage 2
	DFI	ESG_Index	DFI	ESG_Index
DFI_before1	1.014 *** (0.001)			
tele			0.007 *** (0.000)	
DFI		3.089 ** (1.215)		4.847 *** (1.543)
Kleibergen-Paap rk LM statistic P-val		0		0
Kleibergen-Paap rk Wald F statistic		935.003		5618.510
Hansen J statistic		0		0
Control variables	YES	YES	YES	YES
Time effect	YES	YES	YES	YES
Industry effect	YES	YES	YES	YES
N		8256		9730
Adj.R <sup>2</sup>		0.230		0.242

Note: \*\*\* and \*\* indicate significance at the 1% and 5% levels, respectively.

## 5. Further Research: Heterogeneity Analysis

The above research investigated whether and how digital finance can improve corporate ESG performance. However, it remains unclear whether the impact of digital finance on ESG development varies across companies with differing characteristics. Thus, this section aims to investigate the heterogeneous effects of digital finance on the ESG development of various types of enterprises by categorizing them based on region, ownership structure, firm size, and pollution by subsample regression analyses.

### 5.1. Analysis of Regional Heterogeneity

The geographic economics concept of the “Hu Huan Yong line” was employed as a criterion to classify all enterprises into eastern and western enterprises [7]. The empirical results are shown in Panel A of Models (1) and (2) of Table 9, demonstrating that digital finance positively impacts the ESG performance of enterprises in the eastern region and is statistically significant at the level of 5%. However, digital finance showed no statistically significant effect on the ESG level of enterprises in the western region.

The possible reasons for this are as follows. The eastern region is at the forefront of China’s economic and technological development, with a well-established digital infrastructure and a pool of high-caliber technological talent. Consequently, digital finance can be more effectively utilized, thereby assisting enterprises in mitigating financing constraints and boosting their ESG performance. Meanwhile, foreign enterprises predominantly operate in the eastern areas of China, wherein their advanced management models and ESG management concepts may radiate toward domestic firms, motivating them to be more conscious of utilizing financial resources and elevating their ESG levels. In contrast, most of the western regions are still in the nascent stages of internet technology development. The level of technologies such as 5G, blockchain, and others lag behind in the western regions. At the same time, there are also problems, including incomplete digital infrastructure and low coverage of digital finance. Moreover, the western region’s economic development is relatively backward. Some enterprises are still grappling with “survival issues” and can spare little time to prioritize social benefits. These factors make it difficult for digital finance to be as effective as it is at promoting corporate ESG performance in the east.

**Table 9.** Heterogeneity Analysis.

Panel A	ESG_Index		ESG_Index	
	(1)	(2)	(3)	(4)
	East	West	State-Owned	Non-State-Owned
DFI	3.396 ** (1.360)	−7.548 (8.908)	4.738 *** (1.725)	2.493 (1.793)
Cons	−124.381 *** (7.390)	−100.810 *** (26.279)	−107.495 *** (9.164)	−131.307 *** (12.721)
Control variables	YES	YES	YES	YES
Time effect	YES	YES	YES	YES
Industry effect	YES	YES	YES	YES
N	8778	952	5184	4546
Adj.R <sup>2</sup>	0.302	0.332	0.333	0.267
Panel B	ESG_Index		ESG_Index	
	(1)	(2)	(3)	(4)
	Large-Scale	Small-Scale	Polluting	Nonpolluting
DFI	3.303 * (1.742)	3.636 ** (1.617)	3.615 * (2.159)	2.941 * (1.580)
Cons	−105.858 *** (11.076)	−108.132 *** (14.734)	−114.746 *** (12.111)	−129.474 *** (8.498)
Control variables	YES	YES	YES	YES
Time effect	YES	YES	YES	YES
Industry effect	YES	YES	YES	YES
N	4842	4888	3568	6162
Adj.R <sup>2</sup>	0.315	0.224	0.307	0.308

Note: \*\*\*, \*\*, and \* indicate significance at the 1%, 5%, and 10% levels, respectively.

### 5.2. Analysis of Property Rights

In this paper, enterprises were divided into SOEs and non-SOEs according to the nature of property rights. Regression analysis was conducted, and the results are shown in Panel A of Models (3) and (4) in Table 9. The empirical results indicate that digital finance positively affects the ESG performance of SOEs and is statistically significant at the level of 1%. However, digital finance showed no statistically significant promotion of the ESG performance of non-SOEs.

Possible explanations for the differential effect of digital finance on ESG development between SOEs and non-SOEs are as follows. SOEs are used in China as a means to effectively achieve socioeconomic development over a period of time or to improve the country's competitive position in the international market [58], as well as an important tool for the country's sustainable development strategy. SOEs are expected to serve the interests of society, and achieving economic and social development is their primary goal [59]. Additionally, SOEs are subject to higher expectations from the public in fulfilling their social responsibilities, so social supervision pushes them to give great focus to their ESG development. Moreover, digital finance has just started in China, so its application still requires some technical support. SOEs enjoy faster digital transformation rates due to support from national policies, which lay the foundation for implementing digital finance. These direct them to immediately respond and take the lead in promoting high-quality economic development as well as improving their own ESG construction. In contrast, non-SOEs may require more time to adopt new technologies and respond to national policies due to the lack of policy support. Furthermore, contributing to public welfare projects is a long-term investment for companies, but it may lead to increased costs and resource consumption in the short term. Non-SOEs may prioritize economic objectives over ESG goals, making digital finance a weaker driver of ESG development compared with SOEs.



### 5.3. Analysis of Enterprise Size

In this paper, enterprises are divided into large and small according to the median of enterprise size, and regression analysis is conducted. The results are shown in Panel B of Models (1) and (2) in Table 9. The empirical results show that the coefficients of DFI are significantly positive at the levels of 5% and 10%, indicating that digital finance promotes ESG development for both large and small enterprises. The coefficient of DFI is larger in the small enterprise group than in the large enterprise group, which suggests that the effectiveness of digital finance in boosting the ESG performance of small enterprises is stronger.

Possible explanations are as follows. First, digital finance has the characteristic of inclusiveness; the ability to alleviate financing constraints is stronger for SMEs, which often struggle to obtain financing from traditional financial markets. Second, in contrast to large corporations, which are favored by investors in traditional financial markets, the effect of digital finance in solving financial needs provides timely help for SMEs [38]. Moreover, excellent ESG performance helps companies establish a favorable social image, and a good reputation earns the trust of stakeholders, which ultimately increases credibility. SMEs have gaps in size and reputation level compared with large enterprises, so their decision-makers may want to gain social recognition through good ESG performance to help enterprises obtain more social resources [60]. Consequently, digital finance more strongly promotes ESG development for SMEs than for larger firms.

### 5.4. Analysis of Polluting and Nonpolluting Enterprises

The Guidelines on Industry Classification of Listed Companies, promulgated by the Chinese government in 2012, and the 16 categories of heavily polluting industries subdivided in the Management List of Environmental Verification Industries of Listed Companies established in 2008, are employed as criteria to classify enterprises as either polluting or nonpolluting. A regression analysis was conducted, and the results are shown in Panel B of Models (3) and (4) in Table 9. The empirical results show that the coefficients of DFI are both significantly positive at the 10% level, indicating that digital finance promotes the development of ESG for both polluting and nonpolluting enterprises. However, the coefficient of the DFI is larger for polluting groups, which suggests that digital finance is more effective at promoting the ESG performance of polluting firms.

The possible reasons for the empirical results are as follows. First, with increasing government attention on green environmental protection and social welfare, sustainable development has emerged as a crucial theme for China's economic development. Consequently, the regulatory restrictions imposed on polluting industries have become progressively more stringent. Compared with nonpolluting enterprises, polluting enterprises are under greater pressure to transform, which will force companies to be more concerned about their ESG development. Second, in recent years, the green credit business has been widely promoted. The green credit policy has remarkably enhanced the financing constraints and financing costs of heavily polluting industries while financial subsidies for the local governments for such industries were reduced [61]. As a new financing tool, digital finance provides polluting enterprises with an alternative financing channel to obtain funds and invest in ESG projects, effectively alleviating the financial pressure to develop ESG projects and ultimately promoting their ESG performance. Consequently, digital finance more strongly promotes ESG development for polluting enterprises than for nonpolluting enterprises.

## 6. Research Conclusions and Policy Recommendations

With China stepping into the "Digital Finance 2.0 Era" and with the growing awareness of the concept of ESG, whether and how digital finance can promote corporate ESG development has become a significant issue. Using data from listed companies in the Shanghai and Shenzhen stock markets from 2011 to 2017, the aim of this paper was to empirically investigate the impact of digital finance on corporate ESG development and the mechanisms of digital finance that affect ESG development. The paper's findings

are as follows. First, digital finance not only directly improves the ESG performance of Chinese companies but also indirectly promotes it by alleviating enterprises' financing constraints. Financing constraints play a partially mediating role. Second, the promotion of ESG development through digital finance is primarily achieved by enhancing corporate social responsibility and governance performance, not environmental responsibility. Third, the impact of digital finance on corporate ESG development varies according to region, nature of ownership, enterprise size, and pollution classification, with a stronger effect observed in the eastern region, SOEs, small enterprises, and polluting enterprises. The specific mechanism of digital finance for corporate ESG development has been clarified, providing a reference for enterprises to carry out transformation and implement ESG development concepts. Our research provides empirical evidence that the development of digital finance can contribute to the improvement of companies' ESG performance. This finding serves as a reference for enterprises to undertake transformation and upgrade initiatives and implement ESG development strategies. In today's world, sustainability has become a key focus of economic development, and the enhancement of corporate ESG performance is gaining attention from many countries. Our research also offers empirical evidence for policymakers to incentivize corporate ESG development and promote sustainable economic growth. Based on the empirical results of this paper, this article puts forward the following policy recommendations.

First, "ESG financial innovation" should make full use of the enabling role of digital finance in corporate ESG development. With the advent of the digital era, fintech can provide strong financial support for companies implementing ESG strategies. Financial institutions should actively respond to national policies and implement development requirements using digital financial services to facilitate enterprises' green innovation and low-carbon transformation. Additionally, they should develop financial products and credit services aligned with the national ESG characteristics, expand the range of green bonds and public welfare funds, and make the most of the policy-oriented and targeted features of digital finance, thereby amplifying the impact of digital finance on corporate ESG development.

Second, the government should practically guide companies to focus on environmental responsibility performance. In recent years, despite the Chinese government's calls for the environmental development of enterprises, this paper's empirical evidence demonstrates that digital finance primarily promotes corporate ESG development by enhancing corporate social responsibility and governance performance, with limited improvement in environmental responsibility, which may be the result of the shortsightedness and self-interest of corporations. This problem may exist in other countries as well. Therefore, the government should further strengthen its publicity campaigns to guide enterprises into more greatly emphasizing environmental responsibility, protecting the environment as well as conserving resources, and striving for a "win-win" scenario between economic benefits and ecological preservation. Furthermore, incentive policies should be formulated by the government to stimulate green production and innovation as well as to provide tax benefits and resource prioritization to enterprises that fulfill their environmental responsibilities. Additionally, the government should strengthen environmental regulations, improve punitive measures, blacklist enterprises that significantly harm the environment and waste resources, make full use of market supervision to regulate enterprise behavior, and strive to transform the ESG management model that practices the concept of sustainable development into the conscious action of decision-makers.

Third, the government should accelerate the development of digital finance and guide it toward assisting ESG development in lagging western regions and non-SOEs. The People's Bank of China proposed in the Financial Technology Development Plan (2022–2025) to solve the unbalanced and insufficient development of financial technology, promote a sound governance system for financial technology, and improve digital infrastructure. The government should accelerate the construction of digital infrastructure in the western region, improve the level of regional digitalization, promote the development of the "inter-

net+” industry in the western region, assist the development of science and technology in the western region, and provide a strong technical guarantee for digital finance to assist the development of ESG in the west. Non-SOEs play an important role in promoting national economic development and should be given more attention. On the one hand, the government should increase the financial and policy support for non-SOEs, guide them in digital transformation, and improve the technology level of digital finance. On the other hand, the government should encourage them to invest in more ESG projects and improve their ESG levels.

## 7. Limitations and Future Research

However, our study has three limitations. Firstly, the rapid development of digital finance in China raises uncertainty about whether the enabling effect of digital finance on corporate ESG will be significant in other countries. Therefore, policymakers should consider their national conditions when selecting methods to promote corporate ESG. Secondly, since there is no standardized ESG rating system, our study only selected two representative ESG indices, and the scope of ESG coverage may be broader. Thirdly, our findings only represent the relationship between digital finance and ESG from 2011 to 2017. As fintech and corporate management concepts evolve over time, it remains unclear whether digital finance can continue to drive corporate ESG development in subsequent years.

Therefore, future research could validate our findings by using samples from other countries or regions or by considering a wider range of ESG indices. Scholars could also choose a longer time period for their research to explore whether digital finance consistently improves corporate ESG performance.

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