

Can the Promotion of Digitalization Enhance Enterprises' ESG Ratings?

-- Mediating Effect of Executives' Environmental Background

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Abstract: The effect of digitalization on the ESG ratings of a firm is an essential area of debate. Utilizing data collected from A-share public enterprises between 2009 and 2022, this work investigates the implications and processes of digitalization on the ESG ratings of firms. The moderating influence of environmental backgrounds of executives is also examined. The following are the research findings. (1) Corporate ESG ratings has been greatly improved by digitalization. This finding is still reliable in a variety of tests. (2) The environmental backgrounds of executives intensify the positive association between ESG ratings of the firm and digitalization. (3) In accordance with the mechanistic analyses, digitalization advances an organization's ESG ratings through two main channels: strengthening the organization's green innovation and enhancing internal controls. (4) According to the heterogeneity study, strategically emergent, state-owned, eastern and central and significantly polluting businesses are more likely to be impacted by the influence of digitalization on ESG ratings of corporate. In light of this, it is strongly advocated that the government actively furnish policies and institutional circumstances to navigate the dissemination and application of ESG concepts. Meanwhile, it is recommended that enterprises grasp the opportunity of the country's vigorous advancement of digital development and empower all links of enterprise operation and management through digitalization.

Keywords: Digitalization; ESG Ratings; Executives' Environmental Background.

1. Introduction

In the past several years, China has actively supported digitalization and prioritized the advancement of the digital economy. Digital economy in China was worth 53.9 trillion yuan in 2023, or 42.8% of the GDP. Its GDP growth contribution ratio was 66.45% [1]. Digitalization constitutes a crucial assignment for constructing a "digital China" along with a "network power nation". "Changes in the mode of production, lifestyles, and governance driven by the digitalization." provides direction for advancing the digitalization in the new period. In this context, more and more enterprises choose to change their production and operational modes through digitalization[2]. As significant participants in social and economic activities, promoting the enterprise digitalization is a crucial element and approach to building a digital China.

Additionally, "high-quality development is the major task in building a modern socialist country in an all-round way," in accordance with the report of the 20th National Congress of Communist Party of China. Green development, coordination, innovation, shared development and transparency are all included into a single framework in high-quality development. It is a crucial metric for evaluating the high-quality growth of businesses. The improvement of the ESG ratings of businesses to support high-quality development has become a major concern. Following the evolution of the digital economy, digitalization is growing as a significant strategic option for companies to realize high-quality growth. With this in mind, the objective of this article is to examine the effects of digitalization on the ESG ratings of firms together with its underlying mechanisms. As the managers of a company, the executives' decision-making

tendencies will influence the strategic decisions of the company. The top-tier team theory posits that the background characteristics of executives endow them with distinct values and cognitive perspectives, which can significantly influence the strategic decisions of the enterprise[3]. Enterprises may pay more attention to sustainability issues when formulating strategic decisions and disclosing their annual reports if executives have an environmental background. Therefore, do the executives' environmental backgrounds mitigate the effects of digitalization on the ESG ratings? As knowledge on the association between ESG ratings of the firm and digitalization grows, more investigations are being done on how digitalization influences firm ESG ratings. Nevertheless, exploring the moderating role of executive environmental context remains limited. Based on this, this study work is conducted for examining the moderating action of environmental backgrounds of executives besides confirming the effect of digitalization on firm ESG ratings.

This work is performed on the basis of the data gathered from listed companies in the A-share market between 2009 and 2022. Furthermore, a number of tests for robustness were carried out to improve the dependability of results. Additionally, the moderating influence of executives' environmental backgrounds is also examined in this work. Additionally, this work investigates the mechanisms by which digitalization affects the ESG ratings of firms from technological innovation and internal control perspectives. The underlying marginal contributions of this research are as below. (1) In this research, the mediating impact of the environmental context of executives on the impact of digitalization on the ESG ratings of firms is explored. It analyzes whether other factors influence the implications of digitalization, thus magnifying or mitigating its effects. It widens the perspective of research on the association between

digitalization and firms' ESG ratings. (2) This research is intended to clarify the mechanisms by which digitalization affects the ESG ratings of firms from the internal control and technological innovation. The working mechanism of digitalization is elucidated to some extent.

The remainder of this thesis is structured as below. Research hypotheses are proposed and the pertinent literature is reviewed in the second section. Third section presents the research design. Fourth section gives empirical findings. Conclusions and suggestions are given in the fifth section.

2. Literature Review and Hypotheses

2.1. Literature Review

In academic circles, digitalization has attracted a lot of interest. The connotation, determinants, and implications of digitalization have been the main subjects of previous studies. The current literature explains the nature of digitalization mainly from the digital strategy and technology, along with organizational management, and so on. For instance, certain scholars argue that digitalization is a digital technology-driven process designed to promote value creation, business enhancement and related outcomes [4, 5]. According to some scholars, the essence of digitalization is a digital strategy. In especial, it is the utilization of digital technologies or platforms to formulate and execute strategic objectives associated with organizational structures, business models, as well as business processes[6, 7]. At this juncture, the connotation of digitalization extends beyond the technical level. Digital technology serves merely as a means to achieve strategic objectives[8]. Overall, existing research has gradually deepened the comprehension of what digitalization entails. Based on the understanding of digitalization by Hanelt et al. (2020) [9], and other scholars, this paper considers digitalization as a systematic evolution of digital systems involving products or services, business processes, business models, and organizational management, driven by digital technologies. As digitalization progresses, its impact has also garnered significant academic attention. Scholars have attempted to explore the implications of digitalization on the regional society and economy, industrial, and enterprise levels[10-14]. However, available literature does not reach a shared understanding of the implications of digitalization. A number of studies have identified positive impacts of digitalization[15, 16], while others have identified negative impacts[17, 18]. Other studies suggest that the influences of digitalization are uncertain[19, 20]. Overall, the effect of digitalization is still an area worthy of further exploration.

As an important participant in social and economic activities, digitalization of the enterprises has gained scholarly attention. The majority of the available research examines the consequences of corporate digitalization from the standpoints of growth and performance. For instance, current research examines how digital change affects business efficiency[21, 22], technological innovation [23, 24, 25], enterprise investment[26, 27], and enterprise exports[28, 29]. ESG is a key framework for the assessment of environmental, social as well as corporate governance performance of the firm. It can dramatically influence the strategic decisions[30] and has been a critical factor influencing corporate sustainability[31]. ESG is gradually gaining mainstream status and attracting widespread attention from various sectors[32]. However, enterprises still face numerous obstacles in enhancing their ESG practices. For instance,

there is a lack of internal motivation and external incentives to strengthen the ESG ratings[33]. Owing to digitalization is being employed in businesses so widely, researchers are trying to find out how it affects the ESG ratings of corporate[34, 35, 36].

According to the majority of research, digitalization may greatly improve an organization's ESG ratings[37, 38]. The main ways that digitalization improves company ESG ratings are by reducing financial limitations, drawing in more analysts, reducing information asymmetry, enhancing corporate innovation capabilities, strengthening internal controls, and improving financial performance[39, 40]. However, some investigations have also revealed the adverse consequences of digitalization on the ESG ratings of firms. According to Wang & Hou (2024)[41], businesses are more likely to protect their interests when they are dealing with digitalization. A substantial drop in ESG ratings might arise from inadequate investment in external non-operating metrics. Fang et al. (2023)[37] argue that a digital transition can boost an organization's performance in terms of corporate and social governance. However, its impact on the environmental dimension is insignificant. Therefore, the influence of digitalization on governance, social along with environmental performance of corporate is still a significant topic that merits more attention. Additionally, a number of external and internal factors may influence the impact of digitalization on ESG ratings of a company. For instance, scholars have found that stringent environmental regulations enhance the beneficial effect of digitalization on ESG ratings of a company [35].

Digitalization has generally gained more attention in the literature that is now available. However, the association between ESG ratings of a firm and digitalization is comparatively underexamined. Particularly, research on the mediating role of external and internal factors in this relation is limited. In light of this, the objective of this research is to analyze how corporate ESG ratings is affected by digitalization and further validate the mediating effect of the context of the executive environment.

2.2. Hypotheses

ESG is key framework for evaluating a business's governance, social, and environmental performance. It is consistent with the tenets of superior growth. Improving company ESG ratings has become a major priority in many different domains. Nevertheless, there are still obstacles in the way of improving corporate ESG ratings, including a lack of internal and external motivation and practical capabilities[33]. As the digital economy grows, digitalization is becoming more widely acknowledged as a key factor in fostering businesses' sustainable growth[42, 43]. Big data, AI together with cloud computing are examples of digital technologies that are becoming more and more important in company development. The beneficial effects of digitalization on business ESG ratings have also been noted in several research[34, 37]. The application of digitalization in enterprise production and operation activities can reduce transaction costs, and information acquisition costs, and enhance information quality[44, 45]. This will increase both the financial investment and willingness of enterprises to participate in environmental, social as well as governance activities. digitalization is progressively becoming a critical driver for improving the ESG ratings of firms and can also offer technological support for strengthening the capacity of

ESG practices.

Firm ESG ratings is impacted by digitalization primarily through the two pathways listed below. First, corporate green innovation may be greatly enhanced via digitalization, which facilitates the integration of digitalization and corporate sustainability[46, 47]. Second, internal controls of businesses might be strengthened even further through digitalization[48, 49], for instance, via improving the accuracy of information, cutting the cost of information processing, speeding up the collecting of information, and broadening the scope of information gathering. This is beneficial for improving the ESG ratings of businesses and their actual ESG skills. Additionally, other factors may also have an impact on how digitalization influences the ESG ratings of business. The upper echelon theory states that executives' distinct cognition is shaped by their background traits, which in turn influences their decision-making. As key managers of enterprises, executives' decisions significantly impact the strategic decision-making of the organization. Executives with an environmental background develop awareness, values, or decision-making patterns related to environmental protection[3]. More attention will be paid to sustainable development issues and environmental responsibility when making strategic decisions. With the application of digitalization in enterprise production and operation, executives with environmental backgrounds will focus more on the social responsibility, environmental protection as well as corporate governance. This magnifies the influence of digitalization on the ESG ratings.

The hypothesis is presented in this study according to the analysis above:

H1: Enterprise ESG ratings may be considerably enhanced by digitalization.

H2: Through improved internal control and green innovation, digitalization raises ESG ratings.

H3: The favorable correlation between corporate ESG ratings and digitalization may be reinforced by executives having an environmental background.

3. Research Design

3.1. Data

This study utilizes the initial data of A-share public companies between 2009 and 2022 as the sample data. Subsequently, the sample data undergoes a series of preprocessing steps. Firstly, the PT, *ST, and ST samples are excluded. Secondly, samples with severe data deficiency were excluded. Finally, 1% and 99% winsorization were applied to the data. Data are acquired from Sina Finance website and CSMAR database.

3.2. Variables

Dependent Variable: The performance of businesses in terms of ESG. Huazheng ESG ratings are applied in this work to evaluate businesses' ESG ratings. The ESG rating system of Huazheng consists of nine levels, from the lowest (1) to the highest (9), with corresponding values assigned accordingly. The ESG ratings of the firm is expressed by the yearly average score.

Independent Variable: digitalization. This article adopts the methodology of Yuan et al. (2021) [50], which utilizes the overall frequency of digitalization-related phrases in the annual reports of publicly traded companies to indicate the degree of digitalization of a company. The vocabulary related to digitalization selected in this paper mainly includes information, networking, internet, data, artificial intelligence, etc.

Moderating Variable: The environmental backgrounds of senior executives. According to Wang et al. (2022) [51], if a personal resume includes keywords such as "environmental protection," "low-carbon," along with "environment," it is categorized as having an environmental context. This study quantifies the degree of environmental backgrounds of executives via the proportion of executives with an environmental background to the overall number of executives.

Table 1. Explanation of Variables

	Variables	Sign	Explanation
Dependent Variable	enterprises ESG ratings	<i>ESG</i>	Huazheng ESG ratings are based on a scale from 1 to 9 and are averaged annually.
Independent Variable	digitalization of businesses	<i>DT</i>	The logarithm of the total frequency of digitization-associated terms in a company's annual report is calculated.
Moderating Variable	environmental backgrounds of executives	<i>EEB</i>	total number of senior executives having environmental backgrounds/total senior executives number
Control Variables	enterprise age	<i>AGE</i>	Log (observation year-the year of being listed)
	enterprise scale	<i>SIZE</i>	Log (total assets)
	asset-liability ratio	<i>ALR</i>	liability/total assets
	shareholding ratio of the chairman	<i>CSR</i>	number of shares held by the chairman/total share capital
	ratio of the number of independent directors to that of directors	<i>IDR</i>	number of independent directors/total number of directors
	the growth rate of total operating revenue	<i>RGR</i>	(total operating income for the current period - total operating income for the previous period)/total operating income for the previous period
	the net profit rate of total assets	<i>APR</i>	net profit/total assets
	environmental regulation	<i>ER</i>	Log (pollution fees or environmental protection taxes)

Table 2. Descriptive Statistics

Variables	Obs	Mean	Sd	Min	Max
<i>DT</i>	27,052	3.1646	1.2325	0.0000	6.1136
<i>ESG</i>	27,052	4.0163	1.0757	1.0000	6.0000
<i>AGE</i>	25,232	1.9432	0.9425	0.0000	3.2958
<i>SIZE</i>	27,052	22.1374	1.2114	20.0413	25.8269
<i>ALR</i>	27,052	0.4108	0.2025	0.0533	0.8753
<i>CSR</i>	25,794	9.6733	14.72744	0.0000	56.6700
<i>IDR</i>	27,052	0.3823	0.0728	0.2500	0.6000
<i>RGR</i>	27,052	0.1694	0.3593	-0.4916	2.1004
<i>APR</i>	27,052	0.0419	0.0570	-0.1910	0.1999
<i>ER</i>	27,052	13.3526	1.3832	10.2443	17.089
<i>EEB</i>	25,863	0.0724	0.1636	0.0000	1.0000

Control Variables: With a view to avoiding the interference of other factors as much as possible and drawing on the existing literature, the control variables consist of gearing ratio, firm size (measured in terms of total assets), the age of firm, the growth rate of total operating income, the number of independent directors as a percentage of the number of directors, chairman's shareholding ratio, the net interest rate on total assets, as well as the degree of environmental regulation (measured by environmental taxes or pollution fees).

Tables 1 and 2 presents the descriptive statistics. According to Table 2, corporate digitalization has a standard deviation of 1.233, a mean value of 3.165, a maximum and minimum value of 6.114 and 0, separately. It exhibits notable changes in the level of digitalization across various businesses. Enterprise ESG ratings have a standard deviation of 1.076, a mean of 4.016, a maximum of 6 and a minimum of 1. This exhibits variations in enterprise ESG ratings, with overall performance being at a medium-to-low level.

3.3. Model

This study creates the benchmark model below to analyze the effect of digitalization on the ESG ratings.

$$ESG_{it} = \alpha + \beta DT_{it} + \sum CONTROLS_{it} + \lambda_i + \mu_t + \varepsilon_{it} \quad (1)$$

ESG_{it} denotes the ESG ratings of a company. DT_{it} stands for the digitalization of firms. $CONTROLS_{it}$ represents a set of control variables. λ_i and μ_t indicate the individual fixed effects and time fixed effect, separately. ε_{it} is the random error term. In this paper, robust standard errors are adopted in estimating the regression model.

Furthermore, for verifying the moderating action of executives' environmental backgrounds in the influence of digitalization on ESG ratings of the firm, the interaction term of digitalization and the environmental context of executives was introduced, and a moderation effect model was established. The specific formulation is as follows.

$$ESG_{it} = \alpha + \beta DT_{it} + \gamma EEB_{it} + \delta DT_{it} * EEB_{it} + \sum CONTROLS_{it} + \lambda_i + \mu_t + \varepsilon_{it} \quad (2)$$

EEB_{it} denotes the environmental backgrounds of senior executives.

4. Empirical Research

4.1. Baseline Regression Analysis

The findings of the benchmark regression are displayed in Table 3. The findings are revealed in Column 1 based just on the primary explanatory factors. At significance level of 1%, the findings suggest that ESG ratings of business is considerably improved by digitalization. A variety of control variables are included in the second column. The findings suggest that the influence of digitalization on ESG ratings of a firm is still evidently positive. This means that digitalization has markedly enhanced the enterprises' ESG ratings. The research hypothesis H1 is supported. In the third column, to confirm the moderating effect of environmental background of executive, the interaction term between digitalization and executive environmental background is introduced. The outcomes revealed that the interaction coefficient between digitalization and environmental context of executive is markedly positive. This presents that the environmental background of leaders enhances the beneficial effect of digitalization on the ESG ratings of the firm. This means that the greater the proportion of executives having the environmental backgrounds, the greater the positive effect of digitalization on firms' ESG ratings. The results support the research hypothesis H3.

Furthermore, ESG ratings of a firm encompasses its performances in the aspects of environment, society, and governance. This section makes a distinction between the influence of digitalization on governance, social, along with environmental performance. Columns 1, 3, and 5 in Table 4 exhibit the outcomes. These results exhibit that digitalization may considerably improve ESG ratings of an organization. To some extent, this provides evidence supporting the robustness and credibility of the findings of the benchmark regression. The interaction terms between the executives' environmental backgrounds and digitalization have been incorporated in columns 2, 4, and 6 in Table 4 to confirm that the executives' environmental context have a mediating action on how digitalization affects an organization's environmental, social, as well as governance performance. Coefficients of the interaction term between executives' environmental context and digitalization are highly positive, according to the data in columns 2 and 4. It implies that the favorable connection

between corporate social and environmental performance, together with digitalization is reinforced by the environmental backgrounds of executives. Namely, the larger the proportion of executives having an environmental context is, the more it can strengthen the beneficial impact of digitalization on the social and environmental properties of businesses. The result in Column 6 shows that although not statistically significant, the coefficient of interaction term is favorable. This suggests that the executives' environmental backgrounds do not influence how digitalization affects the governance

performance of an enterprise. A possible explanation is that executives having an environmental context are more likely to focus on the company's sustainable development concerns, which amplifies the benefits of digitalization for the social and environmental properties of company. Even though an organization's governance performance is essential to its survival, businesses will stop at nothing to enhance it through digitalization. Although the moderating role of the executives' environmental backgrounds is positive, it is relatively less significant.

Table 3. The outcomes of Baseline Regression Analysis

	(1)	(2)	(3)
Variables	ESG	ESG	ESG
<i>DT</i>	0.0933***	0.0490***	0.0378***
	(10.2720)	(6.2876)	(4.5110)
<i>ENVIR</i>			-0.4841***
			(-3.8070)
<i>DT*ENVIR</i>			0.1319***
			(3.7817)
Constant	3.720***	-1.7794***	-1.5645***
	(127.02)	(-5.9278)	(-5.0468)
Obs	26,965	23,636	22,696
R ²	0.5028	0.6309	0.6341
Control	No	YES	YES
Company FE	YES	YES	YES
Year FE	YES	YES	YES

Note: The t-statistics are represented in parentheses. *, **, and *** denote significance at the levels of 10%, 5%, and 1%, separately

Table 4. Regression Results for the ESG ratings Sub-component

	(1)	(2)	(3)	(4)	(5)	(6)
Variables	E	E	S	S	G	G
<i>DT</i>	0.0487***	0.0398***	0.0558***	0.0456***	0.0431***	0.0359***
	(5.2703)	(4.1452)	(5.6869)	(4.3936)	(3.6104)	(2.8040)
<i>ENVIR</i>		-0.1386		-0.4231***		-0.2683
		(-0.7906)		(-2.6435)		(-1.3374)
<i>DT*ENVIR</i>		0.0837*		0.1287***		0.0608
		(1.6505)		(2.9493)		(1.1287)
Constant	-1.7610***	-1.5102***	-1.2954***	-1.5618***	1.2819***	1.4228***
	(-5.1134)	(-4.3565)	(-3.4582)	(-4.0587)	(2.8130)	(3.0040)
Obs	23,636	22,696	23,636	22,696	23,636	22,696
R ²	0.5945	0.6203	0.5504	0.5567	0.4898	0.4954
Control	YES	YES	YES	YES	YES	YES
Company FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES

Note: The t-statistics are represented in parentheses. *, **, and *** denote significance at the levels of 10%, 5%, and 1%, separately

4.2. Robustness Test

To make sure the benchmark regression findings are reliable and resilient, this study performs a number of robustness tests.

(1) Replace the primary explanatory variable. The percentage of word frequency correlated with digitalization in annual reports of listed firms takes the place of the primary explanatory variable. The outcomes are displayed in Column 1 in Table 5. At the 1% level, digitalization has a substantially

favorable influence on ESG ratings. In other words, the findings of the baseline regression are solid and trustworthy. This study presents an interaction term between the environmental backgrounds of executives and digitalization in Column 2. The findings exhibit that, at the 1% level, its coefficient is markedly positive. In other words, executive environmental backgrounds support the favorable correlation between businesses' ESG ratings and digitalization, hence confirming the validity of the baseline findings. (2) Alter the model specification. In Table 5, Column 3 presents the

outcomes of re-estimating Equation 1 while controlling for both time- and industry-fixed effects. When controlling for time-fixed and city-fixed effects concurrently, the outcomes are exhibited in Column 5. At the 1% significance level, digitalization in both situations considerably improves ESG ratings of the firm, supporting the dependability and validity of the benchmark regression findings. The interaction term

between the digitalization and environmental context of executives is included in both Columns 4 and 6. The favorable correlation between corporate ESG ratings and digitalization is strengthened by the environmental backgrounds of the executives. This validates that the benchmark results are robust.

Table 5. The Outcomes of Robustness Tests

Variables	(1) ESG	(2) ESG	(3) ESG	(4) ESG	(5) ESG	(6) ESG
<i>DTI</i>	6.9482*** (6.3471)	5.8450*** (4.8274)				
<i>ENVIR</i>		-0.1786** (-2.2344)				
<i>DTI*ENVIR</i>		15.9785*** (2.7063)				
<i>DT</i>			0.0583*** (8.0513)	0.0488*** (6.3941)	0.0381*** (5.5968)	0.0256*** (3.5158)
<i>ENVIR</i>				-0.0820 (-0.7075)		-0.2296** (-1.9964)
<i>DT*ENVIR</i>				0.0919*** (2.7617)		0.1401*** (4.2360)
Constant	-1.7617*** (-5.8747)	-1.5431*** (-4.9785)	-1.6747*** (-10.7440)	-1.6152*** (-10.1040)	-2.8118*** (-17.5863)	-2.7690*** (-16.8678)
Obs	23,636	22,696	24,014	23,040	24,003	23,029
R ²	0.6309	0.6340	0.2222	0.2209	0.2252	0.2248
Control	YES	YES	YES	YES	YES	YES
Company FE	YES	YES	NO	NO	NO	NO
Industry FE	NO	NO	YES	YES	NO	NO
City FE	NO	NO	NO	NO	YES	YES
Year FE	YES	YES	YES	YES	YES	YES

Note: The t-statistics are represented in parentheses. *, **, and *** denote significance at the levels of 10%, 5%, and 1%, separately.

4.3. Endogeneity Test

The following strategies are applied in this study to solve the underlying endogeneity problems in the empirical analysis.

(1) Given the possibility of a temporal lag in the influence of digitalization on ESG ratings of the firm, this article introduces digitalization that is one period behind schedule and digitalization that is two times behind schedule as the primary explanatory variables into the benchmark model. At the significance level of 1%, it is discovered that digitalization markedly improves ESG ratings of a company.

(2) The endogeneity issue is addressed by utilizing the instrumental variables technique. The average digitalization level in the sector in which the business operates is chosen as the instrumental variable. The regression outcomes of two-stage least squares method are revealed in columns 3 and 4 in Table 6. The findings of the first stage are displayed in Column 3. At the 1% significance level, it is discovered that the instrumental variable is positive, meeting the relevance requirement. The outcomes of the second stage are displayed in Column 4. At the 1% significance level, it is observed that the LM statistic disproves the null hypothesis of inadequate identification. The null hypothesis of the weak instrumental

variable is rejected since the F statistic, which is 312.689, is higher than the crucial value of 16.38 at the 10% level. At the 5% significance level, digitalization can improve an organization's ESG ratings following adjusting for the endogeneity problem. Additionally, this confirms that the benchmark findings are reliable.

4.4. Mechanism Test

The aforementioned study reveals that digitalization remarkably strengthen the firm ESG ratings. However, it fails to delve into the channels of such an effect. In this regard, this study utilizes Baron & Kenny's (1986) [52] mediation effect test approach to investigate how digitalization improves businesses' ESG ratings from the standpoints of green innovation and internal control. In particular, the total number of green utility model patent applications filed by businesses serves as a proxy for green innovation. The internal control index, which is published by DIB, measures internal control. This index can reflect a company's internal control effectiveness and risk management capabilities.

Table 6. Endogeneity Test Results

	(1)	(2)	(3)	(4)
Variables	ESG	ESG	DT	ESG
<i>DT_1</i>	0.0438***			
	(5.4801)			
<i>DT_2</i>		0.0283***		
		(3.1645)		
<i>DT_iv</i>			0.8748***	
			(17.6800)	
<i>DT</i>				0.1254**
				{2.4969}
Constant	-1.7208***	-2.0298***	-2.5148***	-1.5729***
	(-5.6662)	(-6.3946)	(-6.0100)	{-3.22}
Kleibergen-Paap rk LM statistic				137.862***
Kleibergen-Paap rk Wald F statistic				312.689
Obs	23,268	21,105	23,636	23,636
R ²	0.6322	0.6405	0.5977	0.0653
Control	YES	YES	YES	YES
Company FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES

Note: The t-statistics are represented in parentheses. *, **, and *** denote significance at the levels of 10%, 5%, and 1%, separately

$$ESG_{it} = \alpha_0 + \alpha_1 DT_{it} + \sum CONTROL_{it} + \lambda_i + \mu_t + \varepsilon \quad (3)$$

$$M_{it} = \beta_0 + \beta_1 DT_{it} + \sum CONTROL_{it} + \lambda_i + \mu_t + \tau \quad (4)$$

$$ESG_{it} = \gamma_0 + \gamma_1 DT_{it} + \gamma_2 M_{it} + \sum CONTROL_{it} + \lambda_i + \mu_t + \delta \quad (5)$$

M_{it} serves as a mediating variable. It encompasses green innovation (GI_{it}) and internal control (IC_{it}). The outcomes of mechanism test are exhibited in Table 7.

In Table 7, Column 1 does not incorporate a mediating factor. The findings reveal that digitalization possesses a very favorable impact on business ESG ratings. Column 2 and

Column 4 examine the effect of digitalization on the green innovation and internal control of a company, separately. The findings exhibit that, at the 10% and 1% levels, the benefits of digitalization are quite considerable. Columns 3 and 5 present the findings after incorporating mediating factors. At the 1% level, the regression coefficients for internal control systems and corporate green innovation are both markedly positive, displaying that higher internal control and green innovation levels help to strengthen ESG ratings of a corporate. All of the digitalization regression coefficients are considerably positive. This suggests that the mediating effects of green innovation and internal control are remarkable.

Table 7. Mechanism Examination Results

	(1)	(2)	(3)	(4)	(5)
Variables	ESG	GI	ESG	IC	ESG
<i>DT</i>	0.0490***	0.0087*	0.0485***	0.0061***	0.0425***
	(6.2876)	(1.7585)	(6.2392)	(3.0027)	(3.7058)
<i>GI</i>			0.0560***		
			(4.7431)		
<i>IC</i>					0.5700***
					(8.2908)
Constant	-1.7794***	-0.5772***	-1.7471***	5.9423***	-4.9522***
	(-5.9278)	(-3.3008)	(-5.8313)	(64.9689)	(-8.3964)
Obs	23,636	23,636	23,636	12,640	12,640
R ²	0.6309	0.6288	0.6313	0.3650	0.6141
Control	YES	YES	YES	YES	YES
Company FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES
Sobel Z			1.7260*		2.8670***

Note: The t-statistics are represented in parentheses. *, **, and *** denote significance at the levels of 10%, 5%, and 1%, separately.

Namely, digitalization helps companies to be environmentally and socially responsible via facilitating green innovation, thus strengthening ESG ratings of a firm. It also strengthens the capabilities of risk management and internal controls, which support the realization of key operational, strategic, and governance objectives, further improving ESG ratings. Moreover, this study conducted a Sobel test, where the Z statistic was tested for significance at the levels of 10% and 1%, separately. These findings provide robust evidence for the significant mediating effects. Consequently, research hypothesis H2 is substantiated.

4.5. Further Analysis

The preceding section demonstrated that digitalization positively affect ESG ratings of company. Besides, it was discovered that executives having an environmental background significantly amplify this positive effect. The functioning mechanism was further investigated. This section extends the analysis by examining how digitalization influence ESG ratings of firms in a variety of regions, ownership structures, and industries.

(1) Regional disparities. Columns 1 to 3 in Table 8 illustrate the effect of digitalization on the ESG ratings of firms in the western, central, as well as eastern regions. In the central and eastern regions, digitalization markedly improved

the ESG ratings of firm at the 1% significance level, while in the western region, the effect was positive but not significant. This could be because the digital economy in the central along with eastern regions is more developed than in the western region, and the infrastructure, platforms, and policies associated with the digital economy are more comprehensive in the central and eastern regions than in the western region. This suggests that digitalization can enhance the firms' ESG ratings more successfully. Besides, businesses in the central and eastern regions present a greater desire to strengthen their ESG ratings.

(2) Disparities of enterprise ownership. Columns 4 and 5 of Table 8 illustrate the influence of digitalization on ESG ratings for State-Owned Enterprises (SOEs) and non-SOEs, separately. The outcomes suggest that both non-SOEs and SOEs can evidently strengthen their ESG ratings via digitalization. Nevertheless, in contrast to non-SOEs, SOEs have more pronounced positive influence of digitalization on ESG ratings. The main reason for this is that, in contrast to non-SOEs, SOEs possess more abundant resources in aspects such as finance, materials, human resources, and digital technology. Additionally, they enjoy more rigorous support and constraints in terms of policies and systems. Moreover, they exhibit a stronger willingness and capability to implement ESG principles.

Table 8. Results of Heterogeneity Analysis

	Eastern region	Central region	Western region	SOEs	non-SOEs
Variables	ESG	ESG	ESG	ESG	ESG
<i>DT</i>	0.0506*** (5.5096)	0.0678*** (3.3845)	0.0249 (1.1842)	0.0650*** (4.8793)	0.0345*** (3.2252)
Constant	-1.9499*** (-5.1249)	-2.2563*** (-3.2105)	-1.3482** (-1.9695)	-1.5050*** (-2.9613)	-2.2142*** (-4.9935)
Obs	16,182	4,062	3,388	7,546	13,447
R ²	0.6376	0.5989	0.6313	0.6551	0.6450
Control	YES	YES	YES	YES	YES
Company FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES

Note: The t-statistics are represented in parentheses. *, **, and *** denote significance at the levels of 10%, 5%, and 1%, separately.

(3) Disparities in industrial positioning. In accordance with the industrial categorization and definition of strategic emerging industries in the "Classification of Strategic Emerging Industries (2018)", enterprises were classified as belonging to strategic emerging industries or not according to their industry codes. Subsequently, a grouped regression analysis was performed, and the outcomes displayed in columns 1 and 2 of Table 9 present that digitalization markedly improves the ESG ratings of both groups, with the effect being more noticeable for businesses in strategic emerging industries. The reason lies in that strategic emerging industries are mainly driven by innovation, possess strong radiating and driving forces, and are a significant force to lead the future social and economic development. The state pushes forward the strategic development of emerging industries in terms of systems and policies. Enterprises belonging to strategic emerging industries possess more abundant resources across various dimensions compared to those that do not belong to strategic emerging industries. Moreover, as an emerging industry, it also faces uncertainties in its

development and has a stronger willingness to advance ESG practices. Innovations in digital technologies have a greater effect on their governance, social as well as environmental performance.

(4) Disparities in pollution levels. This part identified whether an enterprise belongs to heavy pollution industries on the basis of the "Guidelines for Environmental Information Disclosure of Listed Companies", "Industry Classification Management List for Environmental Review of Listed Companies," as well as "Industry Classification Guidelines for Listed Companies". The regression analysis for the subgroups was then performed. The outcomes in columns 3 and 4 of table 9 suggest that digitalization noticeably contributes to enhancing the ESG ratings of both groups of firms, with the effect being more noticeable for businesses in heavy pollution industries. The reason lies in that heavy pollution industries are confronted with greater environmental protection pressure, and their environmental protection responsibilities, social responsibilities, and governance obligations are attached great importance by

multiple parties. ESG ratings naturally attracts a lot of interest from many parties since it includes governance, social, as well as environmental aspects. Businesses in high polluting

industries are more ready and able to apply digital technology to advance strengthen ESG ratings and ESG practices as the digital economy grows.

Table 9. Results of Heterogeneity Analysis

	Strategic Emerging Industries	Non-strategic Emerging Industries	Highly Polluting Industries	Non-highly Polluting Industries
Variables	ESG	ESG	ESG	ESG
<i>DT</i>	0.0927***	0.035***	0.0572***	0.0425***
	(5.1137)	(4.12)	(3.8738)	(4.5598)
Constant	-1.5513***	-1.872***	-1.6907***	-1.9142***
	(-2.7519)	(-5.27)	(-3.1462)	(-4.9579)
Obs	5,263	18,373	8,369	15,239
R ²	0.5991	0.641	0.6055	0.6580
Control	YES	YES	YES	YES
Company FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES

Note: The t-statistics are represented in parentheses. *, **, and *** denote significance at the levels of 10%, 5%, and 1%, separately

5. Conclusion

This study examines how the digitalization affects ESG ratings of corporate, the impacting mechanism, and the moderating influence of environmental backgrounds of executive. The findings of the study present that: (1) the ESG ratings of the firm is considerably improved through digitalization. This finding is still true following endogeneity treatment and robustness testing. (2) The positive impact of digitalization on the firms' ESG ratings was improved by the environmental context of executive. (3) Digitalization strengths the ESG ratings of the firm via two major mechanisms: facilitating green innovation and bolstering internal controls. (4) The effects of digitalization on the ESG ratings of companies present significant heterogeneity in different regions, ownership structures, industries, and pollution levels.

In accordance with the conclusions above, the following recommendations are made in this paper. Firstly, relevant government departments should proactively offer policies, and institutional environments to facilitate the digitalization of firm. Meanwhile, governments should actively lead the spread and adoption of ESG concepts and offer support for companies to strengthen their ESG ratings via digitalization. Secondly, company should grasp the opportunity presented by the nation's vigorous advancement in digital development and actively incorporate digital technologies and platforms. Through incorporating digitalization into all aspects of business management and operations, firms can elevate their green innovation capabilities and strengthen internal control mechanisms, thereby enhancing overall ESG ratings. Furthermore, enterprises can raise the ratio of executives having environmental background to amplify the benefits of digitalization.

Acknowledgments

Funding: The Project for Promoting the Basic Research Capacity of Young and Middle-aged Faculty in Higher Education Institutions of Guangxi (2024KY0147); The Research Start-up Project for Introduced Talents of Guangxi Minzu University (22SKQD15); The University-level Research Project of Guangxi Minzu University (2023MDSK

YB13).

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