ISSN 1611-1699 / eISSN 2029-4433

VILNIUS TECH
Vilnius Gediminas Technical University

JOURNAL of BUSINESS ECONOMICS & MANAGEMENT

2025
Volume 26
Issue 4
Pages 982–1006

https://doi.org/10.3846/jbem.2025.24810

HOW DOES DIGITAL TRANSFORMATION MODERATE THE LINK BETWEEN ESG RATINGS AND FINANCIAL CONSTRAINTS?

Huiru CHEN[1], Yunhong HAO[1,2], Yuan LI[3], Ahmad Yuosef ALODAT[1]✉

[1]*School of Business Administration, Zhejiang Gongshang University, Hangzhou, China*
[2]*Zheshang Research Institute, Zhejiang Gongshang University, Hangzhou, China*
[3]*Zhejiang Chinese Medical University, Hangzhou, China*

Article History:
- received 02 March 2025
- accepted 04 August 2025

Abstract. This research aims to examine the moderating role of digital transformation in the link between ESG ratings and financing constraints faced by firms. A sample is a dataset consisting of 4255 listed companies operating in China from 2012 to 2022. The results showed that higher ESG ratings contribute to reducing financing constraints and that digital transformation positively enhances this relationship. In addition, the results also reveal that long-term ESG ratings contribute more effectively to reducing financing constraints. This study provides guidance for managers to practice ESG practices in the long term and insights for firms to find solutions to financing dilemmas. This study's originality lies in demonstrating that higher ESG ratings alleviate financing constraints, with digital transformation enhancing this effect, providing novel insights into the interplay between sustainability efforts and technological advancement in corporate finance. The findings offer valuable implications for firms integrating ESG practices and digital strategies to optimize financial performance.

Keywords: ESG ratings, financial constraints, digital transformation, corporate sustainability, China, moderating effect.

JEL Classification: G30, Q55, Q56.

✉Corresponding author. E-mail: ***ahmad.alodat90@gmail.com***

1. Introduction

With the digital technologies such as artificial intelligence, large models, space computing, and so on on a tear, the 21st century is witnessing a radical transformation in various industries around the world. It significantly enhances corporate sustainability and improves ESG ratings (Hao et al., 2025). Digital transformation fundamentally changes business models to improve corporate efficiency, accelerate manufacturing processes, help create new competitive advantages, and reduce financial constraints and corporate sustainability (Ancillai et al., 2023). Government policies in China and industrial upgrades are accelerating the adoption of digitalization across sectors (Luo et al., 2023). Digital technologies have contributed to enhancing operational efficiency and paved the way for the innovation of new business models, which contribute significantly to achieving environmental and social goals by enhancing operational efficiency, reducing resource consumption, and helping to reduce financial constraints and, thus, corporate sustainability (Mancuso et al., 2023). These technologies have become one of the basic pillars of modern economic foundations (Guo et al., 2024). A vital aspect of

this digital transition is its link to ESG ratings, which influence firms' financial strategies and limitations (Xu & Yin, 2025). Lately, as a determination within corporate sustainability strategies, ESG has significantly impacted investment decisions and access to capital (Alodat & Hao, 2025). Firms with superior ESG ratings frequently have reduced financial limitations, allowing more effective resource allocation to digital transformation efforts (Foley et al., 2024). This drives us to explore the financial constraints of firms after combining the ESG rating and digital transformation.

The firm's main objective is to exploit investment possibilities using the most cost-effective financing (Farooq & Noor, 2023). In an ideal capital market, firms can pursue any lucrative project without depending on internal resources, as external financing incurs no additional cost. Market flaws, including taxes, information asymmetry, and agency conflicts, impose financial limits (Farooq & Noor, 2023). This concept highlights the gap between internal and external sources of financing, which limits a firm's ability to seize available investment opportunities, especially in cases where internal resources are insufficient (Kaplan & Zingales, 1997). In other words, the lack of external capital makes enterprises have to give up favorable investment opportunities, exemplifying financial constraints. Financial constraints refer to an enterprise's incapacity to secure funds for growth opportunities and leverage market investment (Carreira & Silva, 2010). This challenge arises from the firm's difficulty in securing external financing. Financial constraints may hinder the firm's evaluation and effective investment allocation (Ağca & Mozumdar, 2008). Financially constrained firms face high external financing costs, and a large knowledge gap between insiders and investors is often observed (Chen & Wang, 2011). Accordingly, executives and managers may seek to mitigate financial constraints by enhancing ESG rating strategies, which contribute to maximizing long-term firm value.

Given the increasing attention to sustainable finance in countries and regions around the world, assessing the influence of ESG ratings on financial constraints has become a decisivev concern for corporations policymakers, and investors around the world. ESG ratings include effective risk management and regulatory compliance while promoting profitable, resilient business practices, sustainable, and ultimately contributing to alleviating financial constraints (Zhang et al., 2022; Alodat & Hao, 2025). As the firm landscape transforms, enterprises with robust ESG ratings probably overcome financial constraints, attract investment, and enhance their societal and environmental impact (Daugaard & Ding, 2022). Related the effect of ESG criteria on financial constraints, some researchers argue that superior ESG performance can help mitigate these financial constraints (Tan & Zhu, 2022; Fu et al., 2024), while others argue that ESG increases corporate costs (Li & Wu, 2020), And does not alleviate financial constraints. In addition, Miranda-García and Segovia-Vargas (2024) study showed that non-disclosure of ESG information is related to increased funding constraints for listed European firms. Research on the relationship between constraints is still lacking. The results of prior research are inconclusive, which drives us to further study the relationship between the two.

With firms facing increasing sustainability challenges, ESG ratings have become a focus of significant interest due to their direct impact on reputation and long-term financial stability. However, many firms face financial constraints that may hinder the effective implementation of ESG practices. Hence, the importance of examining this complex relationship, especially in light of the accelerating pace of digital transformation, which may play a moderate role in mitigating the impact of financial constraints by improving efficiency, transparency, and access to alternative financing sources.

Previous studies have found that digital transformation reduces financing constraints faced by a firm (Guo et al., 2024; He et al., 2024). Additionally, previous studies have suggested that ESG-related knowledge can directly affect the digital transformation of firms. For example, ESG rating promotes digital transformation (Zhao & Cai, 2023; Wang et al., 2023; Liu et al., 2024; Chen & Ren, 2025), ESG rating divergence reduces the enterprise's digital transformation (Ren, 2025). In line with the significant relationships identified in prior research, we hypothesize that digital transformation moderates the link between ESG ratings and financial constraints. This proposition is consistent with the resource-based view, highlighting technological capabilities' significance in strengthening firm resilience and financial flexibility (Bharadwaj, 2000). Moreover, digital transformation facilitates transparency, operational efficiency, and risk management, which can directly reduce financial constraints and indirectly increase the economic consequences of ESG ratings.

This study purposes to analyze the moderating impact of digital transformation on the link between ESG ratings and financing constraints, with the firms listed sample on the Shanghai and Shenzhen stock exchanges from 2012 to 2022. The focus on the Chinese context acknowledges the unique socio-cultural, legal, and economic factors that may shape the interaction among these variables. By exploring this relationship within China's landscape, we aim to obtain a thorough knowledge of how digital transformation influences the impact of ESG disclosure on financing constraints.

This study makes some contributions and constructs an integrated theoretical framework that includes digital transformation, ESG ratings, and financing constraints. This framework enhances the understanding of technology, environment, and firm performance and provides a theoretical basis for exploring the economic consequences of ESG ratings. Furthermore, it enriches the research related to digital transformation and provides empirical evidence for understanding the emphasis on digital transformation orientation in the era of the digital economy. Furthermore, it enriches the research related to ESG, considering its long-term cumulative impact. Whether the correlation between ESG ratings and financing constraints is negative or digital transformation is a moderating factor, the study's findings confirm that long-term ESG performance outperforms short-term performance. This validates the view that ESG has a cumulative effect and provides solid micro-empirical evidence for strongly calling on firms to implement ESG ratings. The findings offer new ideas for developing country firms to plan their development strategies and pursue competitiveness, and empirical evidence for relevant government policymaking in turbulent environments.

The remaining structure of this paper consists of six sections. Their main contents are as follows: Section 2 develops the hypotheses after the theory is deduced. Section 3 introduces three parts: sample, variables, and model. Section 4 is full of empirical analysis, including basic regression, endogeneity, and robustness tests. Further analysis in Section 5, which consists of a moderating effect and a long-term ESG rating regression. Section 6 discusses study results by comparing them with the relevant literature. Section 7 concludes the research significances, which involve theory and practice, and confesses the shortcomings.

2. Literature review and hypotheses development

2.1. ESG ratings on the financial constraints

ESG is a signalling mechanism that conveys critical corporate sustainability and risk management information to investors and financial institutions. Voluntary disclosure theory and

stakeholder theory can explain their influence on corporate financing constraints. According to Verrecchia (1983), firms aiming for higher ESG ratings tend to enhance disclosure, improving transparency and reducing information asymmetry. ESG disclosure supplements financial information by offering valuable non-financial insights (Dhaliwal et al., 2012), enabling investors to assess firms' conditions better. Higher ESG ratings indicate superior disclosure quality (Baker et al., 2021), facilitating investor confidence, reducing asymmetry, and easing financing constraints. Previous studies have shown a negative effect of ESG on financing constraints (Samet et al., 2018; Farooq & Noor, 2023).

According to stakeholder theory, those firms must address the expectations of multiple internal and external stakeholders to enhance competitiveness and performance (Freeman, 1984). ESG practices serve as a mechanism to fulfill social responsibilities toward various stakeholders, including the environment, community, employees, shareholders, and government, with higher ESG ratings indicating broader stakeholder satisfaction (Alodat et al., 2025). By aligning with stakeholder goals, firms reduce information asymmetry, strengthen their reputation (Zhang et al., 2021), and facilitate resource exchange, ultimately improving resource allocation and easing financing constraints. Firms engaging in ESG ratings are committed to sustainable development beyond financial performance, signalling strong social responsibility to investors and stakeholders. Given the growing emphasis on ESG as a key investment criterion, higher ESG ratings attract capital aligned with long-term growth strategies (Luo & Wu, 2022), diversify funding sources (Kong et al., 2020), and enhance resilience against external economic shocks such as inflation and disasters (Payer et al., 2024). Furthermore, given the above arguments and previous studies, it can be identified that ESG ratings are central to mitigating financing constraints because they increase corporate disclosure, contributing to reducing the information asymmetry gap between firms and stakeholders, thus enhancing transparency and attracting more investors. Therefore, it is hypothesized that there is a significant negative link between ESG ratings on financing constraints. So, the study assumes the first hypothesis:

H1. *ESG ratings have a significant negative effect on financial constraints.*

2.2. Digital transformation's moderating effect

Accelerating the digital transformation and development of actual firms to achieve the integration of digital technology and manufacturing has become an essential task in economic construction (Cheng et al., 2023). By integrating resource-based and stakeholder theories, digital transformation shapes firms' innovation capabilities and sustainable competitive advantages. Wernerfelt (1984) states that firms' heterogeneous resources drive innovation and long-term success. Technological resources, particularly in digitalization and intelligence, are the driving force for sustainable competitive advantage and green innovation (Apostoaie et al., 2025). Emerging technologies such as deep learning, intelligent robots are embedded in various business functions, including R&D, production, operations, and sales. Digital transformation enhances resource allocation by enabling firms to collect and analyze vast data, reducing information asymmetry and operational costs (Cennamo et al., 2020). For instance, analyzing data of customer consumption allows enterprises to tailor services to individual preferences (Chen & Xu, 2023). Additionally, digital technology optimizes green innovation through enhancing resource efficiency, minimizing emissions reduction and energy consumption (Xu et al., 2022). E-commerce can affect climate change is typical evidence (Doran et al.,

2025). More directly, digital transformation is devoted to robust ESG ratings (Zhao & Cai, 2023; Chen & Ren, 2025; Sun et al., 2025).

From the stakeholder theory perspective, digital transformation enhances information exchange between firms and their internal and external stakeholders, fostering reciprocity (Freeman, 1984). By improving digital capabilities, firms increase transparency, allowing suppliers, partners, investors, and customers to gain a more comprehensive understanding of business operations, thereby reducing information asymmetry and strengthening trust and collaboration (Batabyal & Nijkamp, 2016). Additionally, digital transformation enhances information management and corporate governance by enabling real-time communication and collaboration through online tools and sharing platforms, minimizing information delays and distortions (Mourtzis, 2020). Furthermore, visualised data platforms allow shareholders to monitor business activities more effectively, reinforcing oversight, mitigating managerial opportunism, and improving corporate governance standards (Alodat et al., 2025).

Given the above arguments and previous studies, it is believed that digital transformation can improve the internal and external resource allocation and corporate governance level of firms, provide a more transparent implementation environment for ESG activities, reduce the information asymmetry among enterprises, investor and other various stakeholders in ESG practices, and contribute to the reduction of financing constraints. Therefore, the study assumes the second hypothesis:

H2. *A digital transformation positively moderates the connection between ESG ratings and financial constraints.*

Figure 1 illustrates the conceptual model we present.

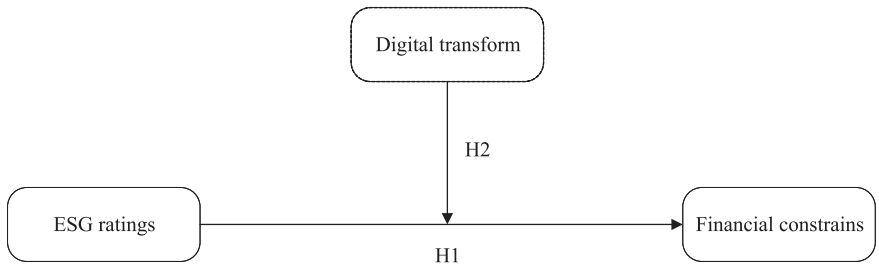

Figure 1. Conceptual model (source: authors' own work)

3. Research method

3.1. Sample selection and data source

A-share firms listed on the Shenzhen and Shanghai stock exchanges are the sample source, within a time frame extending from 2012 to 2022. To mitigate the influence of outliers on the empirical results, we exclude observations pertaining to listed firms designated as ST or *ST during the accounting year, firms in the financial sector, and those with substantial missing data. Continuous variables are winsorized at the 1% level. Following data preprocessing, the final sample comprises 4255 listed firms from the Shenzhen and Shanghai stock exchanges, yielding a total of 30740 observations. Except that ESG ratings are from the Huazheng ESG Rating Reports, the remaining data are primarily sourced from the CSMAR database and firms' annual reports.

3.2. Variable measurement

3.2.1. Dependent variable

Financial constraints measure the difficulties of enterprises to obtain external financing, including loans, credit facilities, and equity issuance, which are necessary to finance their investment and operational activities. These constraints arise from the high cost of lending, insufficient collateral, and a lack of coordination of information between lenders and borrowers. Moreover, Excessive financial constraints will not only limit the investment and financing decisions of firms but also destroy the normal production and operation of firms (Samet et al., 2018). The WW index considers different factors from internal firms and external industries and deletes the influence of TBQ value (Whited & Wu, 2006), which aligns with the immature status of China's stock market, can more truly reflect the financing constraints of Chinese firms, and has broader economic significance. So, we choose the WW index as the primary measure and use the additional two indices as robustness tests.

3.2.2. Independent variable

About international mainstream methods and practical experience, Sino-Securities Index Information Service (Shanghai) developed the Huazheng ESG rating system, tailored to China's national context and the specific characteristics of its capital market. This system provides broader coverage of China's listed firms, and quarterly ranking results are released in a timelier manner, enhancing the effectiveness of analysis and research. They rated ESG based on more than 300 underlying indicators, covering 16 topics: environmental management, climate change, environmental pollution, resource utilization, and environmental friendliness (5 indicators in the E dimension), social contribution, data security, human capital, privacy, supply chain, and product responsibility (5 indicators in the S dimension), external disposition, shareholder rights, governance risk, business ethics, information disclosure quality, and governance structure (6 indicators in the G dimension). Huazheng ESG rating adopts a nine-level rating model: AAA, AA, A, and CCC, CC, C, and BBB, BB, B. Following Zhao and Cai (2023), we select the Huazheng ESG rating index and take the annual average as a proxy measure for the firm's ESG rating. We assign each level of "C-AAA", code 1 to "C", code 2 to "CC", and code 9 to "AAA" according to the increasing rule. The larger the number, the higher the ESG rating.

3.2.3. Moderating variable

Digital transformation is considered one of the decisive factors in the process of building the core competitiveness of enterprises in the digital age. There are two commonly used measurement methods for digital transformation. The first is the questionnaire method. Martínez-Caro et al. (2020) investigated the link between digital technology, organizational culture, and organizational performance using data collected from 93 survey responses. Although the questionnaire will collect as much data as possible to increase the effectiveness of the questionnaire, it isn't easy to ensure that each research object's understanding of the questionnaire is consistent. So, the obtained data based on the questionnaire still cannot measure the digital transformation's adequate content. The second is the text analysis method. Sui et al. (2024) used this method to solve the problem of improving manufacturing firms' competitiveness in digital transformation. Such a treatment scheme was used in this study (Xu & Yin, 2025). The annual report covers corporate strategy, structure, financial level, etc. It can not only reflect the historical situation of firm management but also represent the future development direction of firms (Sui et al., 2024). Therefore, compared with the

questionnaire survey, taking the total word frequency of keywords in the annual report as a measure can improve the scientificity and effectiveness of variable measurement. Following Wu et al. (2022) and Tian et al. (2022), the word frequency statistics method is used to measure the digital transformation by adding 1 to the total word frequency and taking the natural logarithm. This analysis encompasses 75 specific keywords distributed across five categories: digital application technology, artificial intelligence, big data, cloud computing, and blockchain technology.

3.2.4. Control variables

We select 11 indicators as control variables (Chen et al., 2021; Li & Wu, 2020; Gregory, 2022; Tan & Zhu, 2022; He et al., 2023; Farooq & Noor, 2023; Shao et al., 2024; Xu & Yin, 2025), which are firm size (Size), firm leverage (Lev), firm age (Age), return on assets (Roa), cash flow ratio (Cash), firm growth (Grow), capital expenditure (Exp), equity concentration (Top1), industry competition level (HHI), regional marketization level (Mar), institutional shareholding (Ins). In addition, we also control years and industries. The details of all variables are shown in Table 1.

Table 1. Definition and measurement of variables

Description	Var.	Variable measurement	References
Financial constraints	WW	WW Index	Whited and Wu (2006)
ESG rating	ESG	Annual average of Huazheng ESG rating data	Zhao and Cai (2023),
Digital transformation	Digital	Logarithm of the sum of word frequencies for specific terms related to artificial intelligence technologies discussed by management, plus 1	Wu et al. (2022), Tian et al. (2022)
Firm size	Size	Logarithm of the total number of employees	Li and Wu (2020),
Firm age	Age	Logarithm of the years science establishment	He et al. (2023), Xu and Yin (2025)
Firm leverage	Lev	The ratio of total liabilities to total assets	Farooq and Noor (2023), Srivastava et al. (2022)
Return on assets	Roa	The ratio of net profit to average total assets	Li and Wu (2020)
Cash flow ratio	Cash	The ratio of net cash flow generated from operating activities to current liabilities	Xu and Yin (2025)
Firm growth	Grow	The ratio of the current year's operating revenue increase to total operating revenue of the previous year	Farooq and Noor (2023)
Capital expenditure	Exp	The ratio of capital expenditure to total assets	Gregory (2022)
Equity concentration	Top1	Percentage of shares held by the largest shareholder	He et al. (2023)
Industry competition level	Hhi	Herfindahl-Hirschman index	Shao et al. (2024)
Market competition level	Mar	The marketization level of the province where the enterprise is located	Chen et al. (2021)

End of Table 1

Description	Var.	Variable measurement	References
Institutional shareholding	Ins	The ratio of institutional investors' shareholding to total equity	He et al. (2023)
Year	Year	Year FE	Tan and Zhu (2022), Xu and Yin (2025), Shao et al. (2024)
Industry	Ind	Industry FE	Tan and Zhu (2022), Xu and Yin (2025), Shao et al. (2024)

3.3. Model specification

We use a two-way fixed effects model to regress the unbalanced panel data to verify Hypothesis 1 and Hypothesis 2, because the fixed models help us to reduce omitted variable bias (Liu et al., 2023). In addition, it takes into account macro-factor characteristics such as year and industry that have an impact on financial constraints. We develop Model (1) to empirically test Hypothesis 1, where $Controls_{it}$ are all the control variables, θ_i are year-fixed effects, μ_i are industry-fixed effects, and ε_{it} is a disturbance term.

$$WW_{it} = \alpha_0 + \alpha_1 ESG_{it} + \sum Controls_{it} + \theta_i + \mu_i + \varepsilon_{it}. \quad (1)$$

Based on the model (1), we introduce interaction terms to construct a model (2) to test the moderating effect of digital transformation, representing H2.

$$WW_{it} = \alpha_0 + \alpha_1 ESG_{it} + \alpha_2 Digital_{it} + \alpha_3 ESG_{it} \times Digital_{it} + \sum Controls_{it} + \theta_i + \mu_i + \varepsilon_{it}. \quad (2)$$

4. Empirical analysis results

4.1. Descriptive statistics and correlation analysis

Table 2 presents the descriptive statistics results. The mean financial constraint is –0.87, with a maximum value of 0, a minimum value of –1.22, and a standard deviation of 0.36. This indicates that Chinese listed firms generally face financial constraints, but the degree of financial constraints varies among firms. Regarding the independent variable, the ESG rating showed a minimum of 1.25, a mean of 4.16, and a maximum of 6.25. This indicates that different listed firms fluctuate significantly in ESG ratings, but overall, they attach considerable importance to ESG.

In Table 3, from the matrix results of correlation analysis, it can be seen that apart from the coefficient between analyst shareholding and equity concentration exceeding 0.5, the coefficients of other variables are less than 0.5, which confirms that there is no multicollinearity in this study (Ahmed et al., 2006). The results indicate that ESG ratings are negatively and significantly associated with financial constraints (coefficient –0.063, $p < 0.01$). That provides a preliminary basis for verifying the H1. Additionally, the relationships between each control variable and dependent variable are generally significant, ensuring the goodness of fit of the Equation.

Table 2. Descriptive statistics

Variables	Obs.	Mean	Std.	Minimum	Maximum
WW	30 740	–0.877	0.366	–1.226	0.000
ESG	30 740	4.156	1.032	1.250	6.250
Digital	30 740	0.882	1.178	0.000	4.407
Size	30 740	7.699	1.242	4.836	11.187
Age	30 740	19.016	5.757	6.000	34.000
Lev	30 740	0.424	0.202	0.058	0.894
Roa	30 740	0.035	0.064	–0.257	0.197
Cash	30 740	0.232	0.376	–0.541	1.937
Grow	30 740	0.156	0.384	–0.555	2.292
Exp	30 740	0.048	0.045	0.000	0.219
Top1	30 740	0.338	0.148	0.084	0.738
Hhi	30 740	0.118	0.123	0.020	0.740
Mar	30 740	9.880	1.706	4.448	12.864
Ins	30 740	0.432	0.247	0.002	0.909

Table 3. Correlation analysis

	WW	ESG	Digital	Size	Age	Lev	Roa	Cash	Grow	Exp	Top1	Hhi	Mar	Ins
WW	1													
ESG	–0.063***	1												
Digital	0.089***	0.038***	1											
Size	–0.304***	0.196***	0.042***	1										
Age	–0.002	–0.031***	–0.065***	0.057***	1									
Lev	–0.328***	–0.069***	–0.072***	0.358***	0.157***	1								
Roa	0.039***	0.233***	0.017***	0.075***	–0.074***	–0.350***	1							
Cash	0.099***	0.090***	–0.044***	–0.041***	–0.055***	–0.424***	0.429***	1						
Grow	–0.074***	0.007	0.061***	0.012**	–0.059***	0.023***	0.247***	0.020***	1					
Exp	–0.078***	0.095***	–0.071***	0.085***	–0.154***	–0.074***	0.143***	0.149***	0.079***	1				
Top1	–0.057***	0.120***	–0.092***	0.176***	–0.082***	0.047***	0.142***	0.070***	–0.007	0.031***	1			
Hhi	–0.037***	–0.088***	–0.028***	0.065***	0.024***	0.060***	–0.054***	0.012**	–0.025***	0.012**	0.074***	1		
Mar	0.085***	0.095***	0.083***	–0.079***	0.116***	–0.085***	0.035***	0.017***	–0.006	0.023***	–0.061***	–0.042***	1	
Ins	–0.192***	0.106***	–0.096***	0.368***	0.070***	0.200***	0.116***	0.039***	0.032***	0.014**	0.509***	0.111***	–0.120***	1

Note: *** p < 0.01, ** p < 0.5, and * p < 0.1.

4.2. Basic regression results

Step by step, Table 4 column (1) has no control variables, adds control variables of firm characteristics, financial status, and equity-related in column (2), and further adds time and industry control in column (3). Across all three regressions, the ESG coefficient remains significantly negative at p < 0.01, indicating that ESG ratings reduce corporate financial constraints. Even after gradually including control variables, taking into account industry and time effects, the level of statistical significance remained largely unchanged, the coefficient remains negative, and the R-squared value increases, reinforcing the robustness of the findings. These results confirm that strong ESG performance mitigates financial constraints, supporting Hypothesis 1.

Voluntary disclosure theory posits that firms enhance their sustainability disclosures to

provide capital markets with more information and dispel misconceptions. High-quality, comparable disclosures allow firms to signal superior sustainability performance, differentiating themselves from weaker performers (Hummel & Schlick, 2016). ESG ratings attract diverse investors, and prior research confirms a positive correlation between ESG disclosure and corporate value (Dhaliwal et al., 2011; Qiu et al., 2016). A higher ESG score can lead to market overvaluation, facilitating investor engagement and easing financing constraints. Additionally, stakeholder theory emphasizes the interconnectedness of corporate development and stakeholder interests. Firms integrating ESG principles enhance social value and achieve long-term benefits (Fu et al., 2024). Higher ESG-rated firms attract greater stakeholder support, reducing financial risk and strengthening resilience, as evidenced by existing research (Siddique et al., 2021; Fu et al., 2024).

Table 4. Basic regression results

	(1)	(2)	(3)
	WW	WW	WW
ESG	–0.020***	–0.015***	–0.012***
	(0.003)	(0.003)	(0.003)
Size		–0.057***	–0.072***
		(0.005)	(0.004)
Age		0.026***	–0.000
		(0.001)	(0.007)
Lev		–0.351***	–0.301***
		(0.020)	(0.019)
Roa		–0.061	–0.075**
		(0.040)	(0.037)
Cash		–0.017**	–0.016**
		(0.007)	(0.006)
Grow		–0.042***	–0.040***
		(0.005)	(0.005)
Exp		–0.512***	–0.373***
		(0.056)	(0.051)
Top1		0.059*	0.031
		(0.034)	(0.031)
Hhi		0.178***	0.039
		(0.030)	(0.029)
Mar		–0.089***	–0.010***
		(0.004)	(0.004)
Ins		–0.080***	–0.048**
		(0.022)	(0.020)
Year	NO	NO	YES
Ind	NO	NO	YES
Constant	–0.794***	0.190***	–0.002
	(0.012)	(0.044)	(0.126)
Observations	30740	30740	30740
R-squared	0.002	0.062	0.222

Notes: *** $p < 0.01$, ** $p < 0.5$, and * $p < 0.1$. The standard deviation under fixed effect regression is within brackets.

4.3. Endogeneity test

Previous studies have pointed out that ESG inhibits corporate financing constraints (Ge et al., 2020). Therefore, empirical analysis must consider the reverse causality between ratings of the ESG on financing constraints. Furthermore, to avoid the possible problems of self-selection bias, missing variables, and variable measure deviation in the results, we rely on five different endogeneity tests to ensure the results' authenticity and robustness.

4.3.1. Instrumental variable (IV) method

As our preferred solution, the 2SLS method was adopted for this part. The IV was measured by the industry-average ESG score of peer firms (Iv_ESG). The adoption of ESG standards fosters mutual influence among firms within the same industry, as firms often emulate each other's practices. An individual firm's level of compliance is closely linked to the average compliance within its sector, indicating a strong correlation between these variables. However, the average ESG level of peer firms within the same industry can influence a firm's financing constraints only through its impact on the firm's own ESG performance, thereby satisfying the exogeneity condition required for IV. Table 5 column (1) confirms the validity of IV, and column (2) shows that Hypothesis 1 is validated.

Table 5. Endogeneity test of ESG ratings and financial constraints (1)

	(1) The first stage ESG	(2) The second stage WW	(3)	(4)
			WW	WW
ESG		–0.007*		
		(0.004)		
Iv_ESG	–182.443***			
	(1.678)			
L.ESG			–0.010***	
			(0.003)	
L2.ESG				–0.007**
				(0.003)
Size	–0.173***	–0.064***	–0.072***	–0.072***
	(0.004)	(0.002)	(0.005)	(0.006)
Age	–0.005***	0.000	0.003	–0.001
	(0.000)	(0.000)	(0.008)	(0.010)
Lev	–0.523***	–0.382***	–0.322***	–0.341***
	(0.031)	(0.012)	(0.022)	(0.025)
Roa	2.000***	–0.023	–0.106***	–0.150***
	(0.087)	(0.035)	(0.040)	(0.043)
Cash	–0.002	0.009	–0.007	0.008
	(0.144)	(0.006)	(0.007)	(0.008)
Grow	–0.073***	–0.056***	–0.036***	–0.039***
	(0.012)	(0.005)	(0.005)	(0.006)
Exp	1.089***	–0.441***	–0.351***	–0.368***
	(0.108)	(0.042)	(0.061)	(0.069)

End of Table 5

	(1) The first stage ESG	(2) The second stage WW	(3)	(4)
			WW	WW
Top1	0.292***	0.120***	0.069*	0.080*
	(0.036)	(0.014)	(0.036)	(0.042)
Hhi	–0.479***	–0.028	0.048	0.068*
	(0.509)	(0.020)	(0.033)	(0.037)
Mar	0.023***	0.005***	–0.009**	–0.008
	(0.003)	(0.001)	(0.004)	(0.005)
Ins	–0.000	–0.070***	–0.054**	–0.034
	(0.023)	(0.009)	(0.023)	(0.028)
Year	YES	YES	YES	YES
Ind	YES	YES	YES	YES
Constant	844.696***	–0.357***	–0.114	0.030
	(7.745)	(0.054)	(0.158)	(0.194)
Observations	30740	30740	25762	21981
R-squared	0.424	0.312	0.207	0.196

Notes: ***p < 0.01, **p < 0.5, and *p < 0.1. The standard deviation under fixed effect regression is within brackets.

4.3.2. Lagged independent variable

In this part, the core independent variables are lagged for one or two periods, i.e., the current financing constraints are used to regress with the previous ESG (L. ESG) and the first two periods ESG (L2. ESG), respectively. Look at Table 5 columns (3–4), the results support Hypothesis 1.

4.3.3. Propensity score matching

Since other important variables like firm size may also affect financial constraints, propensity score matching is employed. First, the ESG mean in the sample is transformed into a binary variable (0–1), with 1 indicating above average and 0 indicating below average. Second, matching is conducted based on control variables, and the matching effect is validated. The t-values of the ATT estimate for Kernel matching are more significant than 1.96, and the bias values of standardized mean differences between treatment and control groups are less than 10%, indicating sound matching effects. Finally, regression is conducted on the data after matching. Table 6 column (1) confirms Hypothesis 1.

4.3.4. Additional control variables

The effect of ESG on financing constraints is influenced by a number of other factors that, in turn, affect the quality of corporate governance. The model added three controls: analyst attention, media coverage, and CEO duality. Table 6 column (2) shows first hypothesis is still unchanged, which supports the study's results.

Table 6. Endogeneity test of ESG ratings and financial constraints (2)

	(1) Kernel matching	(2)	(3)	(4)
	WW	WW	FC Index	KZ Index
ESG	–0.012***	–0.011***	–0.006***	–0.082***
	(0.003)	(0.003)	(0.001)	(0.011)
Size	–0.072***	–0.067***	–0.085***	–0.123***
	(0.004)	(0.004)	(0.002)	(0.018)
Age	–0.000	–0.000	0.003	–0.091***
	(0.007)	(0.007)	(0.003)	(0.028)
Lev	–0.303***	–0.300***	–0.523***	5.313***
	(0.019)	(0.019)	(0.008)	(0.077)
Roa	–0.077**	–0.020	0.294***	–4.828***
	(0.037)	(0.037)	(0.015)	(0.152)
Cash	–0.015**	–0.015**	–0.020***	–2.433***
	(0.006)	(0.006)	(0.003)	(0.026)
Grow	–0.039***	–0.038***	–0.008***	–0.377***
	(0.005)	(0.005)	(0.002)	(0.019)
Exp	–0.371***	–0.332***	0.052**	0.438**
	(0.051)	(0.052)	(0.021)	(0.213)
Top1	0.030	0.011	0.216***	–0.889***
	(0.031)	(0.031)	(0.013)	(0.128)
Hhi	0.038	0.038	0.013	–0.244**
	(0.029)	(0.029)	(0.012)	(0.121)
Mar	–0.010***	–0.010***	–0.006***	–0.062***
	(0.004)	(0.004)	(0.002)	(0.015)
Ins	–0.049**	–0.018	–0.170***	–0.276***
	(0.020)	(0.020)	(0.008)	(0.083)
Dual		0.010*		
		(0.006)		
Ac		–0.018***		
		(0.003)		
Media		–0.008***		
		(0.003)		
Year	YES	YES	YES	YES
Ind	YES	YES	YES	YES
Constant	–0.002	–0.009	1.418***	4.147***
	(0.126)	(0.126)	(0.052)	(0.522)
Observations	30723	30740	30740	30740
R-squared	0.222	0.224	0.405	0.528

4.3.5. Variable replacement calculation

To reduce bias caused by measurement methods, alternative explanatory variables were selected, with the FC index and KZ index used as replacement variables for financial constraints, and a new regression was conducted. In Table 6, columns (3–4) show that ESG ratings are still negative and significant.

4.4. Robustness tests

4.4.1. High-dimensional fixed effect model test and cluster analysis test

To eliminate interference at the regional and individual levels, Table 7 column (1) indicates that of the high-dimensional fixed-effect model after adding the provincial control variables. Table 7 column (2) shows the regression result of controlling for both provinces and individual clustering. In the above two additional regressions, hypothesis 1 still holds.

Table 7. Robustness tests

	(1)	(2)	(3) Year: 2012–2021	(4) Year: 2013–2022	(5) Manufacturing	(6) Non-manufacturing
	WW	WW	WW	WW	WW	WW
ESG	–0.011***	–0.012***	–0.012***	–0.012***	–0.012***	–0.014***
	(0.002)	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)
Size	–0.063***	–0.072***	–0.072***	–0.076***	–0.088***	–0.056***
	(0.002)	(0.006)	(0.005)	(0.005)	(0.006)	(0.006)
Age	–0.000	–0.001	–0.002	0.003	0.002	–0.001
	(0.000)	(0.006)	(0.008)	(0.008)	(0.009)	(0.011)
Lev	–0.388***	–0.303***	–0.320***	–0.330***	–0.380***	–0.213***
	(0.012)	(0.024)	(0.021)	(0.020)	(0.025)	(0.029)
Roa	–0.015	–0.077*	–0.094**	–0.081**	–0.122**	–0.013
	(0.034)	(0.046)	(0.040)	(0.039)	(0.049)	(0.056)
Cash	0.009	–0.016*	–0.028***	–0.009	–0.016*	–0.026***
	(0.006)	(0.008)	(0.007)	(0.007)	(0.008)	(0.010)
Grow	–0.056***	–0.040***	–0.041***	–0.039***	–0.027***	–0.058***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.007)	(0.006)
Exp	–0.446***	–0.373***	–0.361***	–0.381***	–0.416***	–0.216**
	(0.042)	(0.056)	(0.056)	(0.057)	(0.065)	(0.085)
Top1	0.128***	0.030	0.024	0.037	–0.002	0.083*
	(0.014)	(0.037)	(0.034)	(0.035)	(0.041)	(0.050)
Hhi	–0.031	0.036	0.045	0.053*	–0.015	0.044
	(0.020)	(0.034)	(0.033)	(0.032)	(0.059)	(0.033)
Mar	–0.003	–0.011**	–0.007	–0.011***	–0.015***	–0.006
	(0.004)	(0.005)	(0.004)	(0.004)	(0.005)	(0.006)
Ins	–0.070***	–0.048*	–0.059***	–0.045**	–0.043*	–0.032
	(0.009)	(0.025)	(0.022)	(0.022)	(0.026)	(0.034)
Year	YES	YES	YES	YES	YES	YES

End of Table 7

	(1)	(2)	(3) Year: 2012–2021	(4) Year: 2013–2022	(5) Manufacturing	(6) Non-manufacturing
	WW	WW	WW	WW	WW	WW
Ind	YES	YES	YES	YES	YES	YES
Province	YES	YES	NO	NO	NO	NO
Constant	–0.132***	0.036	–0.007	–0.011	0.220	–0.300
	(0.045)	(0.139)	(0.149)	(0.148)	(0.186)	(0.200)
Observations	30740	30740	26569	28775	20227	10513
R-squared	0.315	0.223	0.214	0.222	0.247	0.184

Notes: ***p < 0.01, **p < 0.5, and *p < 0.1. The standard deviation under fixed effect regression is within brackets.

4.4.2. Testing with different time intervals and sample sizes

We conducted regression analyses using a rolling method for a 10-year sample interval and distinguishing between the manufacturing and non-manufacturing sectors. The results in Table 7 columns (3–6) confirm Hypothesis 1. Thus far, Hypothesis 1 has been validated through over ten additional regression tests beyond the basic regression, which enhances the reliability of the main findings.

5. Additional analysis

5.1. Moderating effect analysis

Table 8 column (1) shows the moderated effect of digital transformation. The coefficient of ESG is negative with 1% significance, and the interaction term (ESG*Digital) is negative with 5% significance. This proves that digital transformation and ESG rating work together to reduce financing constraints. Information asymmetry can be used to explain the results, when ESG ratings alleviate corporate financial constraints by reducing information asymmetry, digital transformation affects the degree of information asymmetry. Specifically, when the level of digital transformation is higher, the alleviating effect of ESG ratings on corporate financial constraints is more substantial, supporting Hypothesis 2.

Table 8. Moderating effect analysis

	(1)
	WW
ESG	–0.009***
	(0.003)
Digital	0.018**
	(0.007)
ESG*Digital	–0.004**
	(0.002)
Size	–0.073***
	(0.004)

End of Table 8

	(1)
	WW
Age	–0.000
	(0.007)
Lev	–0.302***
	(0.019)
Roa	–0.077**
	(0.037)
Cash	–0.015**
	(0.006)
Grow	–0.040***
	(0.005)
Exp	–0.373***
	(0.051)
Top1	0.032
	(0.031)
Hhi	0.042
	(0.029)
Mar	–0.010***
	(0.004)
Ins	–0.048**
	(0.020)
Year	YES
Ind	YES
Constant	–0.014
	(0.126)
Observations	30740
R-squared	0.222

Notes: ***p < 0.01, **p < 0.5, and *p < 0.1. The standard deviation under fixed effect regression is within brackets.

Furthermore, specifically combined with the results of Table 4 column (3) in the basic regression, ESG is negative and significant (coefficient –0.012, $p < 0.01$). After incorporating digital transformation and its interaction term, the coefficient of ESG in Table 8 column (1) remains statistically significant (coefficient = –0.009, $p < 0.01$). Likewise, the interaction term also demonstrates statistical significance (coefficient = –0.004, $p < 0.01$). Comparing the two results, if we only look at the coefficient changes of ESG itself, it seems that digital transformation does not strengthen the ESG ratings' reduction effect on financing constraints. However, the fact is that this result is a reminder that we need to delve further into the effect of ESG on financing constraints in the context of digital transformation. Therefore, a more direct diagram of digital transformation is indispensable to demonstrate. Figure 2 shows that with the continuous improvement of the level of digital transformation, the function image of ESG and financing constraints is steep. This proves that digital transformation can always amplify the reduction effect of ESG on financing constraints.

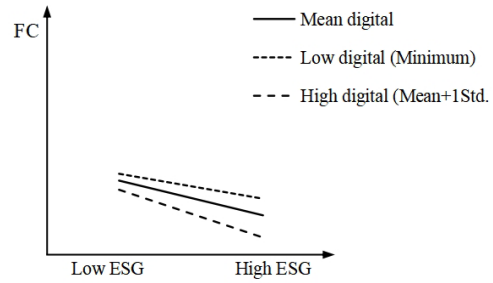

Figure 2. Interaction effect of digital transformation between ESG ratings and financial constraints (source: authors' own work)

5.2. Long-term ESG ratings and financial constraints

Compared with short-term ESG, which can quickly enhance the firm's credibility and image and help the firm obtain timely financing support, long-term ESGs take longer to improve the firm's financial and operating conditions. However, the focus of long-term ESGs is on having a more stable and sustained impact on the enterprises' long-term development. Over a long period, enterprises' participation in ESG activities can lead to higher reputation accumulation and better financial performance, exhibiting a "cumulative effect." Following Shiu and Yang (2017), the calculation by weighting the data from the most recent three periods and assuming that the effect of long-term engagement in ESG ratings gradually decreases within three years. Long-term ESG is calculated and subjected to regression analysis according to the following Equation:

$$Long\_ESG_{it} = \frac{1}{2}ESG_{i,t} + \frac{1}{4}ESG_{i,t-1} + \frac{1}{8}ESG_{i,t-2}. \quad (3)$$

The results in Table 9 column (1) show that Long_ESG is negative and significant (coefficient = –0.015, $p < 0.01$). This indicates that long-term ESG also significantly alleviates financial constraints. Compared to the coefficients for short-term ESG, which ranged from –0.012 to –0.015, the regression coefficient's numerical value suggests that the long-term ESG's alleviation effect is more substantial. Therefore, it can be concluded that compared to short-term ESG performance, long-term ESG performance has a stronger ability to alleviate financial constraints for firms. This result may be because short-term ESG improvement can improve the credibility and image of firms more quickly and help firms obtain financing support more quickly. Still, the persistence of its role may be relatively short. In contrast, long-term ESG improvements can sustainably reduce financial constraints.

Column (2) of Table 9 demonstrates that the coefficient for the interaction term (Long_ESG*Digital) is significantly negative at the 5% level. This indicates that digital transformation strengthens the negative impact of long-term ESG ratings on financial constraints. Furthermore, in comparison to the short-term effects, the coefficients for short-term ESG range from –0.009 to –0.011, while those for the interaction term fall between –0.004 and –0.006. These findings indicate that digital transformation exerts a stronger effect on the process of long-term ESG alleviating the financial constraints.

Table 9. Long-term ESG analysis results

	(1)	(2)
	WW	WW
Long_ESG	–0.015***	–0.011*
	(0.005)	(0.006)
Digital		0.027***
		(0.011)
Long_ESG*Digital		–0.006**
		(0.003)
Size	–0.070***	–0.071***
	(0.008)	(0.008)
Age	–0.005	–0.005
	(0.012)	(0.012)
Lev	–0.384***	–0.384***
	(0.031)	(0.031)
Roa	–0.183***	–0.189***
	(0.050)	(0.050)
Cash	0.013	0.014
	(0.010)	(0.010)
Grow	–0.032***	–0.032***
	(0.007)	(0.007)
Exp	–0.374***	–0.379***
	(0.083)	(0.083)
Top1	0.125**	0.121**
	(0.054)	(0.054)
Hhi	0.039	0.045
	(0.043)	(0.043)
Mar	–0.007	–0.007
	(0.006)	(0.006)
Ins	–0.022	–0.022
	(0.035)	(0.035)
Year	YES	YES
Ind	YES	YES
Constant	0.023	0.006
	(0.255)	(0.255)
Observations	17640	17640
R–squared	0.180	0.181

Notes: ***p < 0.01, **p < 0.5, and *p < 0.1. The standard deviation under fixed effect regression is within brackets.

6. Discussion

The findings highlight the role of ESG ratings in mitigating financial constraints by enhancing firms' legitimacy and attractiveness to investors. Digital transformation strengthens this relationship by improving transparency, operational efficiency, and data accessibility, fostering investor trust and facilitating capital availability. Consistent with prior research, the study confirms the negative association between ESG ratings and financial constraints while emphasizing their contribution to corporate sustainability (Bai et al., 2022; Zhang et al., 2022; Yang et al., 2025). Furthermore, digital transformation moderates this relationship by increasing transparency in environmental and social activities, accelerating data access, and improving risk management. Technologies like artificial intelligence enhance the accuracy and timeliness of ESG assessments, boosting investor confidence. This also provides indirect empirical evidence for the view that technology improves ESG performance (Chen & Zhang, 2025). Additionally, digital advancements enhance cost management and operational efficiency, allowing firms with strong ESG ratings to optimize their capital structure and attract investment.

The study extends ESG practice in digital transformation by bridging the gap between ESG rating research and digital integration. Digital transformation, which involves adopting digital technologies across business operations, enhances the effectiveness of ESG initiatives by improving data management, transparency, and stakeholder engagement. By leveraging digital tools, firms can more accurately track and report their ESG performance, making the information more accessible and reliable (Li & Zhang, 2024). This increased transparency and accountability further reduce financing constraints, fostering investor confidence and facilitating more straightforward access to capital. Furthermore, digital transformation strengthens firms' dynamic capabilities, enabling them to address operational challenges efficiently and ensure the successful implementation of ESG activities (Gao et al., 2024). Furthermore, the findings indicate that ESG ratings and digital transformation work together to ease financing constraints. High ESG ratings reduce information asymmetry and align corporate activities with stakeholder expectations, enhancing investor and creditor confidence. Digital transformation contributes to enhancing these benefits by improving the accuracy and transparency of ESG reporting, leading to increased stakeholder confidence. This synergy positions firms with strong ESG performance and digital capabilities as lower-risk and well-managed, facilitating sustained financial support.

7. Conclusions

This study uses a sample of 4255 Chinese firms from 2012 to 2022, analyzes the direct relationship between ESG ratings and financial constraints, as well as the indirect effect of digital transformation as a moderating variable in this relationship. The findings show that improvements in ESG ratings significantly reduce the enterprise's financial constraints. While digital transformation is a crucial moderator, it further strengthens this relationship. These findings do not run counter to stakeholder theory and support the view that companies with good ESG performance show higher stakeholder commitment, which contributes to increased investor and creditor confidence and reduces financial constraints. Moreover, digital transformation improves transparency and operational efficiency, further reinforcing stakeholder trust and facilitating access to financial resources. The long-term cumulative impact of ESG highlights the sustained benefits of stakeholder engagement, emphasizing that firms integrat-

ing ESG ratings with digital innovation can strengthen financial stability through maintaining strong stakeholder relationships.

This study offers theoretical implications for the correlation of ESG ratings with financial constraints. The finding contributes to the economic impacts literature of ESG ratings by shedding light on the mechanism by which these ratings directly impact financial constraints. The results highlight the value of these ratings in explaining the factors influencing financing constraints, expanding understanding of their financial implications, and drawing researchers' attention to the need not to overlook their role in this context. Second, this research contributes to a deeper understanding of the impact of ESG ratings, taking into account the time dimension, by distinguishing between long-term and short-term ratings and their impact on financing constraints. The findings show that long-term ESG ratings play a more effective role in reducing financial constraints than their short-term counterparts. This enhances the understanding of ESG rating to ease financing constraints and also broadens the understanding of external regulatory forces in corporate governance, which is helpful for the follow-up study of the differences and consistency of the effect of different types of external regulatory bodies on corporate activities. Third, the finding expands the scenario research on the effect of ESG rating on financial constraints at firm level. We find that digital transformation beneficially moderates the process of ESG rating on financing constraints, which directly proves that technical factors magnify the alleviation effect of ESG rating on financial constraints.

This study also contributes to providing practical applications aimed at guiding and improving partial operational processes within the firm. First, enhance emphasis on ESG management. China A-share listed firms should recognize the efficiency of ESG ratings for financing, strengthen their focus and investment in ESG management, and formulate stricter internal management strategies and systems. Second, firms can combine digital transformation with ESG goals, use digital platforms to convey their ESG achievements and efforts to stakeholders, provide online transparency, and make ESG information easier for investors, customers, and employees to access and understand. In addition, digital tools can help firms better collect, analyze, and communicate ESG data, improve the quality and availability of information, enhance the trust and recognition of investors and stakeholders, and further ease financing constraints. Third, actively promote ESG practice and long-term implementation. By integrating ESG factors into corporate culture, business philosophy, and corporate core values, the enterprise can establish an image of sustainable operations and responsible management, thus leading to the entire industry's moral standards. Firms need to establish a complete ESG strategic mechanism to ensure that they can continue to participate in related activities. In the process of long-term participation in ESG activities, firms will gradually form the cumulative effect of ESG moral capital. This means that good ESG performance will be recognized and trusted, thus providing them with more business opportunities and financing channels. ESG is a corporate responsibility and a long-term strategy that contributes to sustainable economic development.

However, there are still some limitations that warrant highlighting and identifying potential avenues for future research. First, the generalizability of the results may be limited by the fact that the data analysis is limited to a sample of Chinese firms. Therefore, future studies would be encouraged to expand the sample to include firms from other emerging and developed economies. Comparisons between samples from China and other countries are also recommended, which would contribute to a deeper understanding of how national characteristics influence the correlation of ESG ratings with financial constraints. Furthermore, such comparisons may shed light on the unique geographical or cultural factors that may

shape this relationship. Second, the research only includes the contextual role of digital transformation without addressing other complementary factors. Therefore, call for future studies should focus on the additional components such as ESG, sustainability initiatives, and corporate social responsibility policies. Exploring these factors could contribute to an integrated framework of the mechanisms of ESG ratings on financing constraints. Third, the theoretical model adopted in this study does not include any mediating variables. Accordingly, future studies could address the mediating role of corporate governance factors, such as analyst interest and media reports, as they may provide new insights and innovative mechanisms for improving ESG performance, in addition to their potential role in mitigating the financial constraints facing firms.

Acknowledgements

The authors acknowledge the support from the Program of the National Social Science Foundation of China (19AGL015; 22CGL063).

Funding

Projects of National Social Science Foundation of China (19AGL015; 22CGL063).

Disclosure statement

The authors declare that there are no conflicts of interest regarding the publication of this article. The study examines the impact of ESG ratings on financial constraints and explores the moderating effect of digital transformation. The authors affirm that the research was conducted independently and without any influence or bias from financial, commercial, or personal interests

References

Ağca, Ş., & Mozumdar, A. (2008). The impact of capital market imperfections on investment–cash flow sensitivity. *Journal of Banking & Finance*, *32*(2), 207–216. https://doi.org/10.1016/j.jbankfin.2007.02.013

Ahmed, K., Hossain, M., & Adams, M. B. (2006). The effects of board composition and board size on the informativeness of annual accounting earnings. *Corporate Governance: An International Review*, *14*(5), 418–431. https://doi.org/10.1111/j.1467-8683.2006.00515.x

Alodat, A. Y., & Hao, Y. (2025). Environmental, social and governance (ESG) disclosure and firm performance: Moderating role of board gender diversity and sustainability committee. *Sustainable Development*, *33*(1), 636–651. https://doi.org/10.1002/sd.3126

Alodat, A. Y., Hao, Y., & Nobanee, H. (2025). How sustainability committees moderate the link between ESG performance and environmental innovation in European firms?. *Business Process Management Journal*. https://doi.org/10.1108/BPMJ-05-2024-0360

Ancillai, C., Sabatini, A., Gatti, M., & Perna, A. (2023). Digital technology and business model innovation: A systematic literature review and future research agenda. *Technological Forecasting and Social Change*, *188*, Article 122307. https://doi.org/10.1016/j.techfore.2022.122307

Apostoaie, C. M., Roman, T. Maxim, A., & Jijie, D. T. (2025). Determinants of AI adoption intention in SMEs. Romanian case study. *Journal of Business Economics and Management*, *26*(2), 277–296. https://doi.org/10.3846/jbem.2025.23650

Bai, X., Han, J., Ma, Y., & Zhang, W. (2022). ESG performance, institutional investors' preference and financing constraints: Empirical evidence from China. *Borsa Istanbul Review*, *22*(S2), S157–S168. https://doi.org/10.1016/j.bir.2022.11.013

Baker, E. D., Boulton, T. J., Braga-Alves, M. V., & Morey, M. R. (2021). ESG government risk and international IPO underpricing. *Journal of Corporate Finance*, *67*, Article 101913. https://doi.org/10.1016/j.jcorpfin.2021.101913

Batabyal, A. A., & Nijkamp, P. (2016). Digital technologies, knowledge spillovers, innovation policies, and economic growth in a creative region. *Economics of Innovation and New Technology*, *25*(5), 470–484. https://doi.org/10.1080/10438599.2015.1073485

Bharadwaj, A. S. (2000). A resource-based perspective on information technology capability and firm performance: An empirical investigation. *MIS Quarterly*, *24*(1), 169–196. https://doi.org/10.2307/3250983

Carreira, C., & Silva, F. (2010). No deep pockets: Some stylized empirical results on firms' financial constraints. *Journal of Economic Surveys*, *24*(4), 731–753. https://doi.org/10.1111/j.1467-6419.2009.00619.x

Cennamo, C., Dagnino, G. B., Di Minin, A., & Lanzolla, G. (2020). Managing digital transformation: Scope of transformation and modalities of value co-generation and delivery. *California Management Review*, *62*(4), 5–16. https://doi.org/10.1177/0008125620942136

Chen, H., & Wang, X. (2011). Corporate social responsibility and corporate financial performance in China: An empirical research from Chinese firms. *Corporate Governance: The International Journal of Business in Society*, *11*(4), 361–370. https://doi.org/10.1108/14720701111159217

Chen, T. T. Liu H. T. Chen R. & Wu L. (2021). The impact of marketization on sustainable economic growth – Evidence from west China. *Sustainability*,*13*(7), Article 3745. https://doi.org/10.3390/su13073745

Chen, Y., & Xu, J. (2023). Digital transformation and firm cost stickiness: Evidence from China. *Finance Research Letters*, *52*, Article 103510. https://doi.org/10.1016/j.frl.2022.103510

Chen, R. X., & Zhang, T. X. (2025). Artificial intelligence applications implication for ESG performance: Can digital transformation of enterprises promote sustainable development? *Chinese Management Studies*, *19*(3), 676–701. https://doi.org/10.1108/CMS-11-2023-0653

Chen, Y., & Ren, J. (2025). How does digital transformation improve ESG performance? Empirical research from 396 enterprises. *International Entrepreneurship and Management Journal*, *21*, Article 27. https://doi.org/10.1007/s11365-024-01011-2

Cheng, X., Xue, T., Yang, B., & Ma, B. (2023). A digital transformation approach in hospitality and tourism research. *International Journal of Contemporary Hospitality Management*, *35*(8), 2944–2967. https://doi.org/10.1108/IJCHM-06-2022-0679

Daugaard, D., & Ding, A. (2022). Global drivers for ESG performance: The body of knowledge. *Sustainability*, *14*(4), Article 2322. https://doi.org/10.3390/su14042322

Dhaliwal, D. S., Li, O. Z., Tsang, A., & Yang, Y. G. (2011). Voluntary nonfinancial disclosure and the cost of equity capital: The initiation of corporate social responsibility reporting. *The Accounting Review*, *86*(1), 59–100. https://doi.org/10.2308/accr.00000005

Dhaliwal, D. S., Radhakrishnan, S., Tsang, A., & Yang, Y. G. (2012). Nonfinancial disclosure and analyst forecast accuracy: International evidence on corporate social responsibility disclosure. *The Accounting Review*, *87*(3), 723–759. https://doi.org/10.2308/accr-10218

Doran, N. M., Manta, A. G., Badareu, G., Berceanu, D., Doran, M. D., & Manta, F. L. (2025). Could e-commerce activities drive to climate change mitigation? Novel evidence from panel quantile regression model. *Journal of Business Economics and Management*, *26*(2), 255–276. https://doi.org/10.3846/jbem.2025.23604

Farooq, M., & Noor, A. (2023). The impact of corporate social responsibility on financial constraints: The role of insider and institutional ownership. *Journal of Financial Reporting and Accounting*. https://doi.org/10.1108/JFRA-10-2022-0368

Foley, A. M., Heffron, R. J., Al Kez, D., Del Rio, D. D. F., Mcinerney, C., & Welfle, A. (2024). Restoring trust in ESG investing through the adoption of just transition ethics. *Renewable and Sustainable Energy Reviews*, *199*, Article 114557. https://doi.org/10.1016/j.rser.2024.114557

Freeman, R. B. (1984). Longitudinal analyses of the effects of trade unions. *Journal of Labor Economics*, *2*(1), 1–26. https://doi.org/10.1086/298021

Fu, C., Yu, C., Guo, M., & Zhang, L. (2024). ESG rating and financial risk of mining industry companies. *Resources Policy*, *88*, Article 104308. https://doi.org/10.1016/j.resourpol.2023.104308

Gao, Y., Yang, H., Sun, X., Tian, X., & Xu, J. (2024). Corporate digital transformation and financing constraints: The moderating effect of institutional investors. *Heliyon*, *10*(12), Article e33199. https://doi.org/10.1016/j.heliyon.2024.e33199

Ge, T., Li, J., Sha, R., & Hao, X. (2020). Environmental regulations, financial constraints and export green-sophistication: Evidence from China's enterprises. *Journal of Cleaner Production*, *251*, Article 119671. https://doi.org/10.1016/j.jclepro.2019.119671

Gregory, R. P. (2022). ESG activities and firm cash flow. *Global Finance Journal*, *52*, Article 100698. https://doi.org/10.1016/j.gfj.2021.100698

Guo, L., Xu, L., Wang, J., & Li, J. (2024). Digital transformation and financing constraints of SMEs: Evidence from China. *Asia-Pacific Journal of Accounting & Economics*, *31*(6), 966–986. https://doi.org/10.1080/16081625.2023.2257235

Hao, P., Alharbi, S. S., Hunjra, A. I., & Zhao, S. (2025). How do ESG ratings promote digital technology innovation?. *International Review of Financial Analysis*, *97*, Article 103886. https://doi.org/10.1016/j.irfa.2024.103886

He, F., Ding, C., Yue, W., & Liu, G. (2023). ESG performance and corporate risk-taking: Evidence from China. *International Review of Financial Analysis*, *87*, Article 102550. https://doi.org/10.1016/j.irfa.2023.102550

He, J., Du, X., & Tu, W. (2024). Can corporate digital transformation alleviate financing constraints?. *Applied Economics*, *56*(20), 2434–2450. https://doi.org/10.1080/00036846.2023.2187037

Hummel, K., & Schlick, C. (2016). The relationship between sustainability performance and sustainability disclosure – Reconciling voluntary disclosure theory and legitimacy theory. *Journal of Accounting and Public Policy*, *35*(5), 455–476. https://doi.org/10.1016/j.jaccpubpol.2016.06.001

Kaplan, S. N., & Zingales, L. (1997). Do investment-cash flow sensitivities provide useful measures of financing constraints?. *The Quarterly Journal of Economics*, *112*(1), 169–215. https://doi.org/10.1162/003355397555163

Kong, Y., Antwi-Adjei, A., & Bawuah, J. (2020). A systematic review of the business case for corporate social responsibility and firm performance. *Corporate Social Responsibility and Environmental Management*, *27*(2), 444–454. https://doi.org/10.1002/csr.1838

Li, J., & Wu, D. (2020). Do corporate social responsibility engagements lead to real environmental, social, and governance impact?. *Management Science*, *66*(6), 2564–2588. https://doi.org/10.1287/mnsc.2019.3324

Li, W., & Zhang, M. (2024). Digital transformation, absorptive capacity and enterprise ESG performance: A case study of strategic emerging industries. *Sustainability*, *16*(12), Article 5018. https://doi.org/10.3390/su16125018

Liu, M., Li, H., Li, C., & Yan, Z. (2023). Digital transformation, financing constraints and enterprise performance. *European Journal of Innovation Management*, *28*(4), 1472–1497. https://doi.org/10.1108/EJIM-05-2023-0349

Liu, Z., Chen, Z., & Hu, L. (2024). Can enterprise digital transformation improve ESG performance?. *Managerial and Decision Economics*, *45*(7), 5088–5103. https://doi.org/10.1002/mde.4307

Luo, K., & Wu, S. (2022). Corporate sustainability and analysts' earnings forecast accuracy: Evidence from environmental, social and governance ratings. *Corporate Social Responsibility and Environmental Management*, *29*(5), 1465–1481. https://doi.org/10.1002/csr.2284

Luo, S., Yimamu, N., Li, Y., Wu, H., Irfan, M., & Hao, Y. (2023). Digitalization and sustainable development: How could digital economy development improve green innovation in China?. *Business Strategy and the Environment*, *32*(4), 1847–1871. https://doi.org/10.1002/bse.3223

Mancuso, I., Petruzzelli, A. M., & Panniello, U. (2023). Innovating agri-food business models after the COVID-19 pandemic: The impact of digital technologies on the value creation and value capture mechanisms. *Technological Forecasting and Social Change*, *190*, Article 122404. https://doi.org/10.1016/j.techfore.2023.122404

Martínez-Caro, E., Cegarra-Navarro, J. G., & Alfonso-Ruiz, F. J. (2020). Digital technologies and firm performance: The role of digital organisational culture. *Technological Forecasting and Social Change*, *154*, Article 119962. https://doi.org/10.1016/j.techfore.2020.119962

Miranda-García, M., & Segovia-Vargas, M. J. (2024). Financial constraints and sustainability in bioeconomy firms. *Global Policy*, *15*(S7), 65–82. https://doi.org/10.1111/1758-5899.13405

Mourtzis, D. (2020). Simulation in the design and operation of manufacturing systems: State of the art and new trends. *International Journal of Production Research*, *58*(7), 1927–1949. https://doi.org/10.1080/00207543.2019.1636321

Payer, R. C., Quelhas, O. L. G., & Bergiante, N. C. R. (2024). Framework to supporting monitoring the circular economy in the context of industry 5.0: A proposal considering circularity indicators, digital transformation, and sustainability. *Journal of Cleaner Production*, *466*, Article 142850. https://doi.org/10.1016/j.jclepro.2024.142850

Qiu, Y., Shaukat, A., & Tharyan, R. (2016). Environmental and social disclosures: Link with corporate financial performance. *The British Accounting Review*, *48*(1), 102–116. https://doi.org/10.1016/j.bar.2014.10.007

Ren, H. (2025). ESG rating disagreement and corporate digital transformation. *Finance Research Letters*, *75*, Article 106903. https://doi.org/10.1016/j.frl.2025.106903

Samet, M., Mouakhar, K., & Jarboui, A. (2018). Exploring the relationship between CSR performance and financial constraints: Empirical evidence from European firms. *Review of Social Economy*, *76*(4), 480–508. https://doi.org/10.1080/00346764.2018.1480795

Shao, Y. T., Qu, L., Liu, P. Z., & Ding, L. (2024). The impact of executive team competency-sharing degree on firm innovation performance. *Journal of Business Economics and Management*, *25*(5), 921–938. https://doi.org/10.3846/jbem.2024.22289

Shiu, Y. M., & Yang, S. L. (2017). Does engagement in corporate social responsibility provide strategic insurance-like effects?. *Strategic Management Journal*, *38*(2), 455–470. https://doi.org/10.1002/smj.2494

Siddique, M. A., Akhtaruzzaman, M., Rashid, A., & Hammami, H. (2021). Carbon disclosure, carbon performance and financial performance: International evidence. *International Review of Financial Analysis*, *75*, Article 101734. https://doi.org/10.1016/j.irfa.2021.101734

Srivastava, J., Sampath, A., & Gopalakrishnan, B. (2022). Is ESG the key to unlock debt financing during the COVID-19 pandemic? International evidence. *Finance Research Letters*, *49*, Article 103125. https://doi.org/10.1016/j.frl.2022.103125

Sui, X., Jiao, S., Wang, Y., & Wang, H. (2024). Digital transformation and manufacturing company competitiveness. *Finance Research Letters*, *59*, Article 104683. https://doi.org/10.1016/j.frl.2023.104683

Sun, T. X., Liu, S. Q., & Guo. M. (2025). Effects of green finance and digital transformation on enhancing corporate ESG performance. *Finance Research Letters*, *74*, Article 106774. https://doi.org/10.1016/j.frl.2025.106774

Tan, Y., & Zhu, Z. (2022). The effect of ESG rating events on corporate green innovation in China: The mediating role of financial constraints and managers' environmental awareness. *Technology in Society*, *68*, Article 101906. https://doi.org/10.1016/j.techsoc.2022.101906

Tian, G., Li, B., & Cheng, Y. (2022). Does digital transformation matter for corporate risk-taking?. *Finance Research Letters*, *49*, Article 103107. https://doi.org/10.1016/j.frl.2022.103107

Verrecchia, R. E. (1983). Discretionary disclosure. *Journal of Accounting and Economics*, *5*, 179–194. https://doi.org/10.1016/0165-4101(83)90011-3

Wang, H., Jiao, S., Bu, K., Wang, Y., & Wang, Y. (2023). Digital transformation and manufacturing companies' ESG responsibility performance. *Finance Research Letters*, *58*, Article 104370. https://doi.org/10.1016/j.frl.2023.104370

Wernerfelt, B. (1984). A resource-based view of the firm. *Strategic Management Journal*, *5*(2), 171–180. https://doi.org/10.1002/smj.4250050207

Whited, T. M., & Wu, G. (2006). Financial constraints risk. *The Review of Financial Studies*, *19*(2), 531–559. https://doi.org/10.1093/rfs/hhj012

Wu, K., Fu, Y., & Kong, D. (2022). Does the digital transformation of enterprises affect stock price crash risk? *Finance Research Letters*, *48*, Article 102888. https://doi.org/10.1016/j.frl.2022.102888

Xu, J., & Yin, J. (2025). Digital transformation and ESG performance: The chain mediating role of technological innovation and financing constraints. *Finance Research Letters*, *71*, Article 106387. https://doi.org/10.1016/j.frl.2024.106387

Xu, Q., Zhong, M., & Cao, M. (2022). Does digital investment affect carbon efficiency? Spatial effect and mechanism discussion. *Science of The Total Environment*, *827*, Article 154321. https://doi.org/10.1016/j.scitotenv.2022.154321

Yang, B., Huang, J. F., & Chen, Y. Z. (2025). The relationship between ESG ratings and digital technological innovation in manufacturing: Insights via dual machine learning models. *Finance Research Letters*, *71*, Article 106362. https://doi.org/10.1016/j.frl.2024.106362

Zhang, D., Wang, C., & Dong, Y. (2022). How does firm ESG performance impact financial constraints? An experimental exploration of the COVID-19 pandemic. *The European Journal of Development Research*, *35*(1), 219–239. https://doi.org/10.1057/s41287-021-00499-6

Zhang, L., Shan, Y. G., & Chang, M. (2021). Can CSR disclosure protect firm reputation during financial restatements?. *Journal of Business Ethics*, *173*, 157–184. https://doi.org/10.1007/s10551-020-04527-z

Zhao, X., & Cai, L. (2023). Digital transformation and corporate ESG: Evidence from China. *Finance Research Letters*, *58*, Article 104310. https://doi.org/10.1016/j.frl.2023.104310