

A study of the impact of digital transformation on corporate financial risk

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ABSTRACT

As China advances toward high-quality economic growth, digital transformation has become a crucial strategy for improving corporate financial oversight and reducing financial risks. Drawing on panel data from A-share non-financial firms listed in Shanghai and Shenzhen between 2014 and 2022, this study employs a text analysis approach to construct a digital transformation index. The findings reveal that increased digitalization significantly lowers financial risk, even after accounting for industry, temporal effects, and potential endogeneity. Further analysis identifies financial flexibility as a partial mediator, with ESG performance and digital financial inclusion acting as respective positive and negative moderators. Additionally, The impact of digital transformation differs depending on the type of firm, regions, technological classifications, and ESG levels. This research deepens the understanding of how digital strategies interact with financial vulnerabilities and offers actionable insights for firms seeking to improve digitalization and risk resilience.

KEYWORDS

digital transformation; financial risk; financial flexibility; ESG; Digital HPFI

1 Introduction

With China shifting its focus toward sustainable and high-quality economic development, the nation has witnessed notable improvements in institutional effectiveness and market mechanisms. These changes, along with evolving macroeconomic policy frameworks, have emphasized the growing significance of accounting information in both micro and macroeconomic decision-making. Simultaneously, the acceleration of technological innovation and industrial restructuring has prompted businesses to reimagine their management and operational models. The integration of digital technologies has transformed the accounting landscape, reshaping functions, structures, and tools. The Ministry of Finance's 2021 blueprint for accounting reform underscores a vision of digital and intelligent financial systems, aimed at enhancing data quality and corporate risk detection capabilities^[1].

At present, the impact of digital transformation has been widely discussed in the academic community, mainly in terms of enterprise risk management, financial management model change, and strategic adjustment. In terms of the impact of digital transformation on enterprise risk taking, digital transformation affects the level of enterprise risk taking and financial stability by improving the level of internal control, reducing environmental uncertainty, and improving enterprise profitability. On the one hand, digital transformation improves the internal control of funds and reduces the cost of internal control by optimizing information processing technology, thus improving the financial stability of enterprises. On the other hand, digital transformation also requires enterprises to innovate the financial risk management mechanism, build an information sharing platform, improve the financial risk early warning system, and increase the early warning of non-financial indicators to cope with the new type of financial risk in the digital environment^[2]. The digital transformation of enterprises positively affects their finance performance. By enhancing operational efficiency, reducing costs, and increasing revenue, digital transformation leads to improved financial outcomes for businesses^[3]. In summary, digital transformation impacts enterprise financial risk in two ways. Enterprises should leverage digital technology to mitigate traditional financial risks, and actively deal with the new types of risks brought about by digitalization to ensure the soundness and compliance of financial management.

Therefore, this paper combines theoretical analysis and empirical research on non-financial listed companies in Shanghai and Shenzhen A-shares from 2014 to 2022 to explore the specific path of the impact of digitalization on enterprise financial risks, identify possible types of risks, and propose corresponding preventive countermeasures. This research contributes to the theoretical framework of corporate digital transformation and financial risk management. It also offers practical guidance for businesses to effectively mitigate financial risks and achieve sustainable development in the digital era.

The primary contributions of this study are: (1) to develop a theoretical framework for analyzing the relationship between digital transformation and financial risk; (2) to utilize empirical methods to assess the effect of digital transformation on corporate financial risk; (3) to combine the results of the study with optimization suggestions for corporate financial risk management and control in the digital environment. The research methods mainly include literature review, data analysis, and regression modeling, etc., with the aim of providing reference for corporate managers, investors, and policy makers.

2 Theoretical analysis and research hypothesis

With the widespread adoption of next-generation digital technologies enterprises have witnessed notable improvements in the efficiency, transparency, and reliability of financial management, internal controls, and disclosure practices. These advancements help mitigate issues related to asymmetric information and managerial moral hazard. By streamlining operations, enhancing resource allocation, and strengthening risk monitoring, digital tools bolster firms' capacity to manage and withstand financial pressures, thereby reducing their vulnerability to financial distress. Furthermore, digital transformation enhances access to external capital and improves recognition in financial markets, contributing to stronger liquidity positions and more stable financing channels^[4]. Hypothesis 1: Digital transformation reduces the financial risk of listed firms.

2.1 Financial Flexibility as a Mediating Channel

Financial flexibility refers to a firm's adaptive capacity to deploy financial resources efficiently in response to changing internal or external circumstances while maintaining ongoing operations. As a dynamic risk-buffering mechanism, it plays a pivotal role in corporate risk mitigation strategies^[5]. According to both the resource-based view and buffer theory, firms can build resilience by accumulating strategic resources that serve as shock absorbers in times of uncertainty^[6]. Specifically, financial flexibility—embodied in liquidity reserves and flexible debt structures—can shield enterprises from volatility and unexpected financial strain^[7]. Digital technologies improve the precision of data collection, resource allocation, and liquidity management, thereby reinforcing this flexibility. Hypothesis 2: Digital transformation lowers financial risk by enhancing firms' financial flexibility.

2.2 ESG Performance as a Moderating Variable

ESG performance reflects a firm's overall commitment to sustainable development. High ESG scores can enhance stakeholder trust, mitigate risk exposure, and strengthen long-term strategic positioning. Companies with robust ESG practices are better equipped to coordinate resources, adapt to external pressures, and integrate digital innovations in a structured and responsible manner^[8].

During digital transformation, firms with stronger ESG profiles can more effectively navigate initial disruptions and amplify the positive effects of digitization. Therefore, ESG is expected to play a strengthening role in the relationship between digital transformation and financial stability. In addition, studies have shown that ESG performance can increase a company's resilience to external shocks and market uncertainty, thereby promoting its stable development in the process of technological change^[9]. In the process of digital transformation, companies with high ESG levels are more likely to demonstrate stronger capabilities in data governance, technology ethics and stakeholder communication, thereby effectively mitigating financial instability in the early stages of transformation. At the same time, ESG is also likely to enhance firms' ability to assimilate new technologies and translate them into financial performance by facilitating cross-functional collaboration and resource coordination^[10]. Hypothesis 3: ESG performance positively moderates the impact of digital transformation on corporate financial risk.

2.3 The Moderating Role of Digital Inclusive Finance (HPFI)

The digital financial inclusion index captures the accessibility and inclusiveness of digital financial services within a region. While HPFI generally enhances financing access, transaction efficiency, and risk management capabilities, its influence on financial risk may be context-dependent^[11]. In regions with high HPFI, easier access to funding may encourage over-expansion among digitally immature firms, inadvertently increasing financial risk^[12]. Therefore, under specific conditions, HPFI may dilute the risk-reducing effect of digital transformation by enabling risky financial behaviors, especially among less capable firms^[13]. In the process of digital transformation, HPFI can play a "double-edged sword" role. On the one hand, it can support the transformation and upgrading of enterprises by improving their access to resources and the efficiency of financial services; on the other hand, if enterprises have not yet established risk management mechanisms commensurate with the degree of digitalisation, the convenient financing channels provided by HPFI may weaken their vigilance and control over risks^[14]. In particular, for enterprises that are still in the early stages of digital transformation and have a low level of internal governance, overreliance on the financial resources provided by HPFI may lead to a mismatch of resources and an increase in debt servicing pressure, which in turn counteracts the risk-mitigating effect that digital transformation is supposed to bring. Therefore, it is reasonable to assume that in regions with high levels of HPFI, the dampening effect of digital transformation on firms' financial risk may be weakened, manifesting itself as a "negative moderating effect". Hypothesis 4: HPFI negatively moderates the relationship between digital transformation and corporate financial risk.

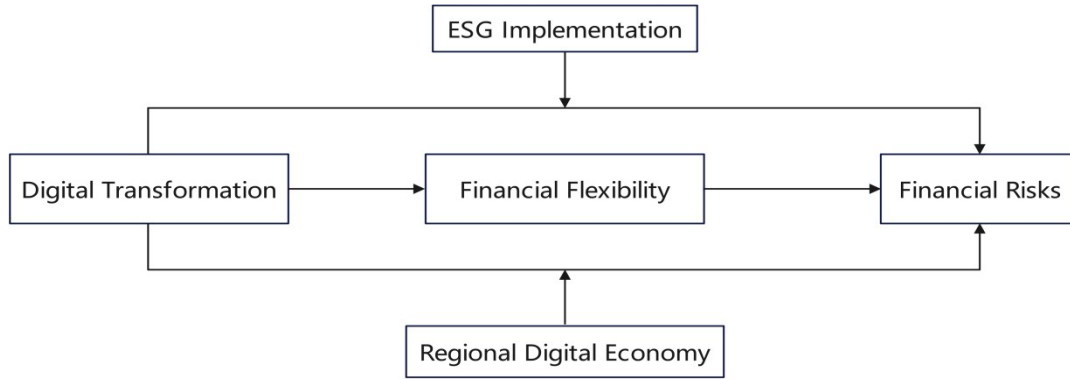


Figure 1 Path diagram of the impact of digital transformation on enterprise financial risk

3 Empirical Design

3.1 Sample selection and data sources

This study analyzes non-financial A-share companies listed on the Shanghai and Shenzhen Stock Exchanges from 2014 to 2022. The dataset is obtained from the CSMAR database and refined according to established standards in the literature. The following screening criteria were applied: (1) firms in the financial and insurance sectors were excluded; (2) companies classified as ST, ST*, or PT were removed; (3) firms with a debt ratio exceeding 1 were eliminated; and (4) observations with missing key financial indicators from 2014 to 2022 were discarded. To reduce the impact of outliers, all continuous firm-level variables were winsorized at the 1% level on both ends. The final sample consists of 16,848 observations.

3.2 Model Construction and Variable Definition

3.2.1 Model Construction

To assess the impact of digital transformation on corporate ESG performance, this paper develops the following benchmark regression model:

$$Z_score_{it} = \beta_0 + \beta_1 DIGI_{it} + \gamma Controls_{it} + \mu_i + \sum IND + \rho_t + \varepsilon_{it} \quad (1)$$

Where the explanatory variable Z_score_{it} represents the financial risk of enterprise i in year t , and the explanatory variable $DIGI_{it}$ is the enterprise digital transformation index, which is used to measure the degree of enterprise i 's digital transformation in year t . $Controls_{it}$ is a number of columns of enterprise-level control variables. In addition, in order to control the impact of unobservable factors on corporate financial risk, firm fixed effects, industry fixed effects and time fixed effects are added to the equation. This paper focuses on the coefficient β_1 of the core explanatory variables, and if β_1 is negative, it means that digital transformation does reduce financial risk.

3.2.2 Definition of variables

(1) The explanatory variable is the financial risk of the enterprise. The most intuitive way to measure the financial risk of an enterprise is the Z_score , which is a comprehensive indicator based on the Altman-Z econometric model, reflecting the relative size of the enterprise's bankruptcy risk, and the higher the value, the lower the financial risk of the enterprise, and the higher the risk. The higher its value, the lower the financial risk of the enterprise, and vice versa, the higher the risk. This index has strong stability and applicability in measuring the financial health of enterprises and has been widely used in related research.

(2) This paper focuses on the degree of enterprise digital transformation as the primary explanatory variable, using the DIGI index for measurement. This index reflects the mentions of digital strategy, technology investment, platform development, and digital business growth as found in the annual reports of listed companies. The index system is created through text analysis that quantitatively scores the frequency of keywords related to digitalization in enterprises, resulting in a comprehensive score for digital transformation. Higher scores indicate a greater degree of digital transformation within these enterprises. Existing literature primarily includes two approaches: that of Chenyu Zhao (2021) in "Finance and Trade Economics" and Wu Fei (2021) in "Management World." To enhance the robustness of the indicators, this paper adopts Chenyu Zhao's methodology, which analyzes the frequencies of 99 digitization-related words across four dimensions in the annual reports of listed companies: digital technology application, Internet business models, intelligent manufacturing, and modern information systems^[15], which is comparatively wider than the 76 digitization-related word frequencies of Wu Fei. related word frequencies cover a wider range.

(3) Control Variables: Following the existing literature, this paper controls firm-level characteristics such as Size, Age,

Tang, ROA, ROE, Lev, CR, Cashflow, TobinsQ, and Top1 as control variables. The specific definitions are shown in Table 1.

Table 1 Definition of Main Variables

Variable	Variable Symbol	Variable Description
Financial risk	Z_score	Measure using the adjusted Altman Z-index model
Degree of digital transformation	DIGI	Ln (Number of keyword disclosures for enterprise digital transformation+1)
Financial flexibility	FF	Corporate financial flexibility=cash flexibility+liability flexibility
Corporate ESG performance	ESG	Annual average ESG score of Huazheng Securities
Digital Inclusive Finance	DIFI	Peking University Digital Inclusive Finance Index/100
Enterprise size	Size	Natural logarithm of total assets at year-end
Enterprise age	Age	Ln (year - listing year+1)
Asset structure	Tang	Ratio of tangible assets to total assets
Return on asset	ROA	Net profit / average total assets
Return on equity	ROE	Net profit / average equity
Asset liability ratio	Lev	Total liabilities/ total assets
Current ratio	CR	Current assets/current liabilities
Cashflow ratio	Cashflow	Operating cash flow / total assets
Enterprise Value	TobinsQ	Market value/total assets
The ratio of shares owned by the largest shareholder to the total number of shares	Top1	Shares held by largest shareholder / total shares

3.3 Descriptive statistics

Descriptive statistics indicate notable variation in DIGI, with scores ranging from 0 to 6.999 and a standard deviation of 1.221. Z-scores vary widely from -0.912 to 37.97, suggesting significant heterogeneity in firms' financial stability.

The mean firm size is 22.09, while Lev is approximately 0.403, indicating moderate debt usage. The average ROA and ROE are 3.6% and 4.5%, respectively, reflecting modest profitability. TobinsQ averages 2.153, and Top1 averages around 32.94%, showing moderate equity concentration. These metrics confirm a diversified sample suitable for empirical analysis.

Table 2 Basic statistical characteristics of main variables

Variable	Sample size	Mean	Median	Std	Min	Max
Z_score	16848	5.245	3.323	6.038	-0.912	37.97
DIGI	16848	3.214	3.178	1.221	0	6.999
Size	16848	22.09	21.92	1.251	19	26.19
Age	16848	2.082	2.197	0.872	0	3.497
Tang	16848	0.335	0.323	0.167	0	0.909
ROA	16848	0.0360	0.0390	0.0730	-0.321	0.272
ROE	16848	0.0450	0.0680	0.171	-0.952	0.449
Lev	16848	0.403	0.389	0.204	0.0540	0.954
CR	16848	2.683	1.816	2.633	0.296	16.61
Cashflow	16848	0.0550	0.0530	0.0760	-1.686	2.222
TobinsQ	16848	2.153	1.690	1.431	0.836	8.954
Top1	16848	32.94	30.75	14.27	8.350	74.66

4 Empirical results and analysis

4.1 Benchmark regression analysis

The core regression estimates demonstrate that the DIGI exerts a statistically significant negative effect on Z-score values across all model specifications. The coefficients of DIGI range from -0.222 to -0.761 and are consistently significant at the 1% or 5% levels, reinforcing the conclusion that enhanced digitalization is associated with reduced financial risk. These findings remain robust when incorporating industry and time fixed effects.

Among control variables, firm age exhibits a significant negative relationship with financial stability, indicating that older enterprises may encounter growing rigidity or reduced innovation capability, thereby elevating financial risk. In contrast, TobinsQ and Top1 are positively correlated with Z-scores, implying that firms with stronger market expectations or concentrated ownership are more financially resilient.

Table 3 Benchmark Regression

	(1)	(2)	(3)	(4)
	Z_score	Z_score	Z_score	Z_score
DIGI	-0.761*** (0.079)	-0.227*** (0.087)	-0.391*** (0.081)	-0.222** (0.087)
Size			0.095 (0.131)	0.035 (0.128)
Age			-1.173*** (0.184)	-0.105 (0.228)
Tang			0.025 (0.670)	-0.564 (0.663)
ROA			-1.291 (1.723)	-0.254 (1.681)
ROE			0.653 (0.692)	0.265 (0.679)
Lev			-0.643 (0.537)	-0.802 (0.511)
CR			0.013 (0.036)	0.010 (0.034)
Cashflow			0.526 (0.575)	0.148 (0.580)
TobinsQ			0.534*** (0.048)	0.079 (0.050)
Top1			0.024*** (0.008)	0.019** (0.007)
Constant	10.353*** (1.603)	7.730*** (1.577)	7.910** (3.561)	7.056** (3.471)
Observation	16848	16848	16848	16848
Industry	YES	YES	YES	YES
Year	NO	YES	NO	YES
R ²	0.043	0.127	0.074	0.129

4.2 Endogeneity issues

4.2.1 Lagged core variables

To mitigate reverse causality concerns, the model introduces a one-period lag of the digital transformation variable (L. DIGI). Results continue to show significantly negative coefficients (ranging from -0.285 to -0.540), confirming that past digitalization efforts have enduring effects in mitigating financial risk.

Table 4 Results of lagged regression of core variables

	(1)	(2)	(3)	(4)
	Z_score	Z_score	Z_score	Z_score
DIGI	-0.222** (0.087)			
L.DIGI		-0.291*** (0.095)	-0.540*** (0.093)	-0.285*** (0.095)
Constant	7.056** (3.471)	7.893*** (2.330)	11.281** (4.571)	11.300** (4.489)
Control	YES	NO	YES	YES
Observation	16848	11879	11879	11879
Industry	YES	YES	YES	YES
Year	YES	YES	NO	YES
R ²	0.129	0.153	0.104	0.157

4.2.2 Instrumental variable method

In order to further alleviate the endogeneity problem, this paper adopts the instrumental variable method to carry out two-stage least squares regression^[16], which shows that enterprise digital transformation promotes the fulfillment of corporate social responsibility, which in turn enhances the enterprise value, and therefore selects "the average level of digital transformation in the same region, industry and year" as the instrumental variable, which replaces the enterprise's own digital transformation index. Therefore, "the average level of digital transformation in the same region, industry and year" is chosen as the instrumental variable to replace the enterprise's own digital transformation index^[17]. This

instrumental variable is exogenous and relevant: on the one hand, the overall digitization degree of the industry and region in which the enterprise is located will significantly affect its own digitization level; on the other hand, there is no direct causal path between this variable and the financial risk of individual enterprises, which meets the requirements of instrumental variable setting.

The results from the 1st stage regression analysis reveal a significant positive correlation between the instrumental variables and the level of digital transformation within enterprises.

This indicates that the instrumental variables possess strong explanatory power regarding the DIGI and meet the necessary correlation conditions.

In the 2nd stage, the results show that the digital transformation index, adjusted for instrumental variables, continues to have a significant negative impact on financial risk. This further confirms the reliability and causal relationship of digital transformation in reducing financial risk.

Table 5 Results of instrumental variable regression

Variables	2SLS	
	1st stage X	2nd stage Y
IV	0.675*** (0.022)	
DIGI		-0.430** (0.204)
Control	YES	YES
Cragg-Donald Wald F statistic		2110.09
Kleibergen-Paap rk Wald F statistic		1524.35
Kleibergen-Paap rk LM statistic		639.66***
HansenJ statistic P		0.000
Observation	16848	16261
Industry	YES	YES
Year	YES	YES
R-squared	0.386	0.128

4.3 Robustness test

To ensure the robustness of the main regression results, this paper tests the impact of DIGI on corporate financial risk in a variety of ways. The six sets of regression models in the table are adjusted from two perspectives: sample selection and variable substitution to verify the stability of the estimated coefficients of the digital transformation variables.

After excluding the sample with zero digitization level (column 1), the coefficient of DIGI is -0.263 with a significance level of 1%, indicating that digital transformation continues to significantly reduce corporate financial risk even after excluding firms that have not undergone any digitalization.

Further, the coefficients of DIGI are -0.331 and -0.132 when restricting the sample to 2016 and later years^[18] (Column 2) and excluding high-tech firms (Column 3), respectively, with the former reinforcing the conclusions of the main regression results while the latter may indicate that high-tech firms have a different mechanism or moderating effect between digitalization and financial risk.

When the sample of municipalities^[19] is further excluded (Column 4), the coefficient of DIGI is -0.211, which is still at the significance level, showing that the regional factor does not substantially change the relationship between the variables, and the results are robust.

Table 6 Regression results of robustness test

	(1)	(2)	(3)	(4)
	Remove DIGI=0	After 2016	Remove samples of high-tech enterprises	Remove municipalities directly under the central government
DIGI	-0.263*** (0.094)	-0.331*** (0.091)	-0.132 (0.128)	-0.211** (0.098)
Constant	8.262** (3.339)	5.244* (2.954)	10.169** (4.871)	8.113** (3.864)
Control	YES	YES	YES	YES
Observation	16635	12853	6454	13665
Industry	YES	YES	YES	YES
Year	YES	YES	YES	YES
R ²	0.127	0.062	0.084	0.123

5 Mechanism analysis

5.1 Mediating effect model construction

To examine how digital transformation mediates financial risk, this paper develops the following econometric regression model:

$$FF_{it} = \alpha_0 + \alpha_1 DIGI_{it} + \gamma Controls_{it} + \mu_i + \sum IND + \rho_t + \varepsilon_{it} \quad (2)$$

In model (2), the explanatory variable FF_{it} is financial flexibility, and the main explanatory variable $DIGI_{it}$ characterizes the enterprise digital transformation index.

The parameter to be estimated α_1 measures the effect of digital transformation index on financial flexibility.

5.2 Construction of the Moderating Effect Model

To examine the moderating mechanism of digital transformation on financial risk, this paper constructs the following econometric regression model:

$$Zscore_{it} = \theta_0 + \theta_1 DIGI_{it} + \theta_2 DIGI_{it} * ESG_{it} + \gamma Controls_{it} + \mu_i + \sum IND + \rho_t + \varepsilon_{it} \quad (3)$$

$$Zscore_{it} = \delta_0 + \delta_1 DIGI_{it} + \delta_2 DIGI_{it} * DF_{it} + \gamma Controls_{it} + \mu_i + \sum IND + \rho_t + \varepsilon_{it} \quad (4)$$

In Model (3), the parameter represents the direct effect of DIGI on Z_score, while the parameter captures the moderating effect of the ESG score on the relationship between digital transformation and financial risk. In Model (4), the parameter measures the direct impact of DIGI on Z_score, and the parameter reflects the moderating effect of the Digital Inclusive Finance Index on the influence of digital transformation on financial risk.

5.3 Regression Results Analysis

The regression results presented in Table 7 indicate that, after incorporating the mediating variable of financial flexibility, the relationship between digital transformation and financial flexibility is significantly negative. In contrast, the effect of financial flexibility on financial risk is significantly positive. Additionally, the direct impact of digital transformation on financial risk continues to be significantly negative, implying that financial flexibility serves as a mediating factor in this relationship.

These findings confirm Theoretical Hypothesis 2 proposed in this paper: digital transformation indirectly reduces financial risk by enhancing a firm's financial flexibility.

On one hand, digital tools strengthen enterprises' refined capital management and dynamic fund allocation capabilities, thereby improving their financial resilience to external shocks.

The digitalization process may involve short-term increases in investment and adjustments in operational models, which can temporarily reduce financial flexibility—subsequently influencing the level of financial risk faced by the enterprise.

Table 7 Regression Results of Mediating Effects

	(1)	(2)	(3)
	Z_score	FF	Z_score
DIGI	-0.222** (0.087)	-0.016** (0.007)	-0.208** (0.086)
FF			0.861** (0.394)
Constant	7.056** (3.471)	0.657*** (0.134)	6.491* (3.435)
Control	YES	YES	YES
Observation	16848	16848	16848
Industry	YES	YES	YES
Year	YES	YES	YES
R ²	0.129	0.034	0.137

Table 8 presents the results of the Bootstrap test, conducted to further verify the mediating effect of financial flexibility in the relationship between digital transformation and financial risk.

As shown in the table, the confidence interval for the indirect effect of digital transformation on financial risk does not include zero, providing further evidence that financial flexibility serves as a mediator in this relationship^[20], thereby supporting Hypothesis 2.

Table 8 Bootstrap mediation test

	Observed coefficient	Bootstrap std. err.	z	P> z	Normal-based [95% conf. interval]	
indirect	-.055318	.0265514	-2.08	0.037	-.1073579	-.0032781
direct	-.5445905	.0563204	-9.67	0.000	-.6549765	-.4342046

	Observed coefficient	Bias		Bootstrap std. err.	Bootstrap [95% conf. interval]	
indirect	-.05531799	-.0073932		.02655144	-.1202415	-.0276577 (P)
					-.1084401	-.0273893 (BC)
direct	-.54459051	.0102212		.05632039	-.6422969	-.4226229 (P)
					-.657486	-.4431344 (BC)

The regression results presented in Table 9 indicate a significant relationship between DIGI and the Z-score. In Column (1), the coefficient for DIGI is -0.222, which is significant at the 5% level. This suggests that, without considering moderating variables, the degree of digitalization has a significant negative impact on the dependent variable.

As we introduce moderating variables into the model, the relationship evolves. In Column (2), we add the interaction term ESG $\times$ DIGI. Here, the coefficient for the interaction term DIGI $\times$ ESG is 0.048 and is significant at the 1% level. This implies that ESG scores positively moderate the effect of digitalization on the dependent variable. Specifically, as ESG performance improves, the negative impact of digitalization on the dependent variable lessens and may even turn positive.

Column (3) further examines how Digital Integration in Financial Institutions moderates the relationship between digitalization and corporate performance. The findings indicate that the coefficient for DIGI is 0.607, which is significant at the 1% level. Additionally, the coefficient for the interaction term DIGI $\times$ DIFI is -0.003, also significant at the 1% level. This indicates that the progress of inclusive finance somewhat reduces the beneficial effect of digitalization on corporate performance. These findings confirm Hypotheses 3 and 4.

Table 9 Regression results of moderation effect

	(1)	(2)	(3)
	Z_score	Z_score	Z_score
DIGI	-0.222** (0.087)	-0.421*** (0.115)	0.607*** (0.205)
DIGI*ESG		0.048*** (0.016)	
DIGI*DIFI			-0.003*** (0.001)
Constant	7.056** (3.471)	7.132** (3.508)	8.051** (3.483)
Observation	16848	16759	16845
Industry	YES	YES	YES
Year	YES	YES	YES
R ²	0.129	0.131	0.132

6 Heterogeneity Analysis

To better understand the varying effects of digital transformation on financial risk, this study conducts subgroup analyses across multiple dimensions: firm ownership, geographic location, technological classification, and ESG performance levels. These dimensions capture structural and institutional differences that may moderate the relationship between digitalization and financial outcomes^[21].

6.1 Ownership Type

Results reveal that for non-SOEs, the digital transformation index has a significantly negative impact on financial risk, suggesting that privately held firms derive more immediate risk-reduction benefits from digital upgrades. In contrast, the coefficient for SOEs is also negative but not statistically significant, indicating a weaker effect. This may be due to more rigid structures or slower implementation of technological changes in SOEs.

6.2 Regional Distribution

Enterprises are further classified based on geographic regions—eastern, central, and western China. In the eastern region, where digital infrastructure and policy support are more advanced, digital transformation significantly reduces financial risk. In the central region, the effect remains negative but is less robust. Interestingly, in the western region, the coefficient turns positive and is statistically insignificant, reflecting underdeveloped digital environments and lower transformation effectiveness.

6.3 Technological Classification

Next, firms are divided into high-tech and non-high-tech groups. Among high-tech enterprises, digital transformation is significantly associated with reduced financial risk. However, in the non-high-tech group, the relationship is not significant. This suggests that firms already operating in technology-intensive industries may be more capable of integrating and benefiting from digital strategies.

6.4 ESG Performance Differences

Grouping by ESG score reveals further heterogeneity. Firms with lower ESG scores (below a threshold of 7) exhibit a significant negative correlation between digitalization and financial risk, implying that such firms may still rely heavily on digital tools to stabilize operations. Conversely, for firms with strong ESG performance (scores ≥ 7), digitalization has a significant positive effect on financial resilience, suggesting synergy between responsible governance and digital infrastructure.

In summary, the impact of digitalization on corporate performance exhibits significant heterogeneity, shaped by firm ownership, regional development level, technological attributes, and sustainability capacity. Policymakers and corporate managers should adopt tailored strategies that align with local conditions and firm-specific characteristics when advancing digital transformation initiatives.

Table 10 Heterogeneity Regression Results

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	SOE=0	SOE=1	East	Mid	West	Hightech=0	Hightech=1	ESG<7	ESG $\geq$ 7
DIGI	-0.218** (0.110)	-0.213 (0.136)	-0.235** (0.099)	-0.237 (0.255)	0.122 (0.234)	0.058 (0.117)	-0.385*** (0.128)	-0.221** (0.087)	3.135*** (0.000)
Constant	8.466* (4.613)	7.397 (5.612)	6.848* (4.053)	12.379* (7.385)	0.670 (7.386)	13.657*** (5.253)	-0.175 (4.354)	7.225** (3.513)	157.524*** (0.020)
Control	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observation	12357	4491	12485	2455	1907	6047	10801	16731	117
Industry	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year	YES	YES	YES	YES	YES	YES	YES	YES	YES
R ²	0.154	0.116	0.134	0.169	0.166	0.164	0.141	0.130	1.000

7 Conclusion and Recommendations

In light of China's accelerating digital transformation and evolving economic landscape, this study investigates whether and how digitalization influences corporate financial risk. Using a panel dataset of A-share non-financial firms listed in Shanghai and Shenzhen from 2014 to 2022, the research constructs a digital transformation index and employs the Altman Z-score to evaluate financial risk. Through a combination of fixed-effects regression, lagged variables, instrumental variable methods, and robustness checks, the study identifies a robust negative relationship between digital transformation and financial risk, along with key intermediary and moderating mechanisms.

Digitalization not only directly reduces financial risk but also indirectly enhances financial resilience through improved financial flexibility. Additionally, ESG performance amplifies the benefits of digital transformation, while digital financial inclusion may, under certain conditions, weaken its risk-mitigating effects. These insights offer practical implications for policymakers, businesses, and investors aiming to leverage digital strategies for financial stability.

7.1 Policy Recommendations for Government

As the architect of the economic and institutional environment, the government should play a guiding and supportive role in advancing corporate digital transformation.

First, it should continue improving laws, regulations, and standards related to the digital economy, clarifying corporate

responsibilities and norms in areas such as data governance, information disclosure, and financial digital operations to prevent deviations like “misguided transformation” or “technological idling.”

Second, stronger policy support should be directed toward small and medium-sized enterprises, including financial subsidies, tax incentives, and easier financing access, to lower the marginal cost of digital upgrading and prevent the widening of the “digital divide.”

Third, the government should invest in digital infrastructure development, especially in central and western and underdeveloped regions, to bridge regional digital gaps and promote coordinated regional economic development, thereby enhancing firms’ risk resilience at the systemic level.

7.2 Strategic Recommendations for Enterprises

Enterprises should emphasize the deep integration of digital transformation strategies with financial governance. Digital tools should be leveraged to improve financial control efficiency, optimize resource allocation, and enhance financial flexibility. Firms should strengthen digital financial systems, promote business-finance integration, and deploy tools such as big data analytics, robotic process automation in finance, and intelligent early-warning systems to enable early risk identification, alert, and response^[22].

Moreover, building financial flexibility is essential. Firms should optimize capital structures and liquidity management to increase resilience in a volatile economic environment. For highly leveraged firms, particular caution is advised when assessing the initial investments and financing risks of digital projects to avoid secondary risks from over-indebtedness.

Additionally, ESG principles should be embedded throughout the digital transformation process—from strategy and corporate culture to specific management practices—to fulfill sustainable development requirements. This approach will enhance both external capital market recognition and internal governance efficiency, achieving dual value creation through “technological advancement + responsibility fulfillment”^[23].

7.3 Guidance for Investors

As key participants in market resource allocation, investors should adapt their risk identification and decision-making frameworks in response to accelerating digital transformation. They should look beyond financial statements and evaluate digital strategy execution—such as the intensity of technology investment, digital platform development, and smart operation indicators—alongside firms’ financial flexibility to assess risk tolerance and transformation feasibility.

Furthermore, attention should be paid to ESG performance, which affects both risk exposure and financial stability. ESG metrics should be incorporated into investment analysis models to enhance portfolio resilience and long-term return potential.

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