Scientific Research Publishing

iBusiness, 2024, 16, 195-215
https://www.scirp.org/journal/ib
ISSN Online: 2150-4083
ISSN Print: 2150-4075

The Impact of Digital Transformation on the Debt Financing Costs of Small and Medium-Sized Enterprises

Haopeng Zhang

School of Management, University of Shanghai for Science and Technology, Shanghai, China
Email: zhang482225662@163.com

How to cite this paper: Zhang, H. P. (2024). The Impact of Digital Transformation on the Debt Financing Costs of Small and Medium-Sized Enterprises. *iBusiness, 16,* 195-215.
https://doi.org/10.4236/ib.2024.164014

Received: October 10, 2024
Accepted: November 30, 2024
Published: December 3, 2024

Abstract

Based on the relevant theoretical analysis of corporate debt financing costs, this paper takes the small and medium-sized enterprises listed in China from 2009 to 2023 as samples, constructs digital transformation indicators, and empirically tests the impact of digital transformation of small and medium-sized enterprises on their debt financing costs and its mechanism by using the individual time two-way fixed effect model. The research results show that under the condition of fixed individuals and time, the digital transformation of SMEs can significantly reduce their debt financing costs and pass the robustness test. Further exploring the reasons, it is found that enterprise digital transformation can reduce the debt financing cost of SMEs by increasing the media's attention to enterprises and enhancing the financial stability of enterprises. The study also found that the effect of digital transformation on the reduction of debt financing costs of SMEs is more obvious in non-state-owned enterprises or SMEs located in central and eastern regions or in regulated industries. This paper has enriched the research on the impact of digital transformation on microeconomic entities, provided new ideas for easing the financing constraints of SMEs, and also provided a reference for promoting differentiated support policies for enterprises' digital transformation and the transformation of old and new driving forces in the real economy.

Keywords

Digital Transformation, Middle and Small-Sized Enterprises, Debt Financing Cost, Information Asymmetry

1. Introduction

In today's world, the flourishing development of the digital economy has become

the core driving force behind global economic growth. Especially in China, with the rapid advancement of digital technologies such as big data, artificial intelligence, cloud computing, and blockchain, almost all industries are undergoing digital transformation, and the role of digitalization is an important guarantee for the development and growth of enterprises. The report of the 20th National Congress of the Communist Party of China clearly pointed out that it is necessary to accelerate the construction of Chinese path to modernization, comprehensively build a digital China, realize the deep integration and development of the digital economy and the real economy, and create a number of digital industrial clusters with international competitiveness and influence, which are consistent with China's sustainable development strategy.

The cost of raising funds through debt is crucial for the operation of a company, as it directly affects its financial condition and profitability. Small and medium-sized enterprises play a crucial role in the economic development of various countries, but they often face challenges such as difficulty in obtaining loans and high loan costs. In indirect financing, traditional financial institutions tend to favor large enterprises in order to ensure safety when issuing loans, which leads to higher costs, greater risks, and difficulty in matching returns and risks for small and medium-sized enterprises in financial business. In direct financing, the asymmetry of market information exacerbates the difficulty for small and medium-sized enterprises to enter, leading to a decrease in investors' willingness and credit limits for loans to small and medium-sized enterprises, which further increases the obstacles for small and medium-sized enterprises in the financing process.

Digital transformation is based on advanced information technologies such as cloud computing, big data analysis, and artificial intelligence, and through the integration of digital technologies, it completely reforms enterprise business models and operational processes to improve efficiency and reduce costs. Advanced digital technology can improve the quality of information disclosure, alleviate information asymmetry and other problems, and provide new ideas for alleviating the financing difficulties of small and medium-sized enterprises. Based on this, the remaining of the study is structured as follows. Firstly, this paper reviews the relevant literature on the digital transformation of SMEs and the debt financing cost and the development status of China, and then analyzes the impact mechanism of digital transformation on the debt financing cost of SMEs based on the theories of information asymmetry, agency cost, signal theory and puts forward research hypotheses, and then conducts empirical analysis, selects 1940 SMEs listed in China from 2009 to 2023 as samples, constructs digital transformation indicators, and uses the two-way fixed effect model for empirical testing. Finally, robustness test and heterogeneity analysis were carried out.

2. Theoretical Analysis and Research Hypothesis

Research on debt financing reveals the complexity of the impact of various factors

on the cost of corporate debt financing and the financing constraints of small and medium-sized enterprises, including internal factors such as executive academic experience (Zhou, Ma, & Wu, 2017), internal controls (Chen & Zhou, 2014), and debt financing structure (He & Zhu, 2006); External environmental factors such as market interest rates (Huang & Wang, 2023), legal environment (Liu, Zhang, & Zhou, 2016), and political connections (Zhao, Sun, & Chen, 2019). These studies provide theoretical support for enterprises to formulate debt financing strategies, emphasizing the need for enterprises to seek the optimal capital structure based on comprehensive consideration of internal and external factors, in order to achieve a balance between risk and return and promote long-term stable development of enterprises. However, there is little research on the influencing factors of financing constraints for small and medium-sized enterprises from the perspective of digital transformation.

The China Academy of Information and Communications Technology defined enterprise digital transformation in its "Blue Paper Report on Enterprise Digital Transformation" as "involving the comprehensive digitization of various elements and links of the enterprise using digital technology, optimizing resource allocation such as technology, business, talent, and capital, reconstructing business processes and production methods, aiming to improve enterprise economic efficiency and reduce operating costs." Scholars have explored the connotation of enterprise digital transformation from different perspectives, including technology, data, organizational change, and value creation. Although the definition of digital transformation is not yet unified, it is widely believed that digital technology is the core tool for transformation, aimed at bringing efficiency improvements and cost reductions to enterprises.

Li Guangzi and Liu Li (2009) believe that digital transformation mainly alleviates the problem of corporate financing constraints by reducing the degree of information asymmetry. Information asymmetry is one of the main reasons for corporate financing constraints. For example, under information asymmetry and risk aversion preferences, large banks often "hesitate to lend", leading to high debt financing costs for private enterprises. Nie Xiuhua et al. (2021) believe that digital finance, supported by digital technology, effectively alleviates the possible information asymmetry between the supply and demand sides of funds in lending, expands financial coverage, reduces financial service costs, and meets the sustained and stable funding needs of small and medium-sized enterprises for financial services. Zhao Yue and Tan Zhibo (2012) believe that information asymmetry has led to the inability of traditional credit models designed with collateral, interest rates, and other means by banks to meet the financing needs of some small and medium-sized enterprises, resulting in credit mismatches. The launch of e-commerce platforms has increased the information advantage of enterprises, making it easier for them to obtain bank loans. In empirical research, different scholars have supported this viewpoint by using macro data of provincial digital finance (Huang et al., 2021) and micro data of listed companies. In summary, digital

transformation plays a unique role in alleviating financing constraints for enterprises. On the one hand, digital transformation of enterprises has high homology and similarity with the underlying technology of financial technology, and the development of financial technology can provide favorable technological infrastructure for enterprise financing; On the other hand, financial technology relies on digital technology, with low data processing costs, low risks, and high information flow rates, improving the accuracy and efficiency of financial services and supporting real economy projects, and meeting the financial capital required for enterprise digital transformation (Wu et al., 2021).

Signal theory suggests that in markets with asymmetric information, the party with more information can reduce the information gap and influence the behavior or decisions of the other party by sending signals. Digital transformation can convey positive market signals to investors, customers, and other stakeholders by improving the transparency and efficiency of enterprise operations, indicating that the enterprise has lower operational risks and stronger competitiveness. Digital transformation is beneficial for improving data accessibility and information transparency, and the quality of information disclosure can significantly reduce the debt financing constraints of enterprises. Companies with higher quality of information disclosure are more likely to obtain bank loans and commercial credit; Compared to enterprises facing lower market risks, the quality of information disclosure has a more significant impact on the debt financing constraints of enterprises with higher market risks (Zhang & Bai, 2016). Li Qingyuan, Li Yu, and Zhang Yin Sainan (2023) found that the digital transformation of customer enterprises in the supply chain alleviates the "bullwhip effect" of the supply chain and has a significant positive information spillover effect on supplier enterprises. The digital transformation of customer enterprises improves the information environment between supply chains by reducing the information search and verification costs of supplier enterprises. Shu Wei and Chen Ying (2024) investigated the impact and mechanism of digital transformation on commercial credit financing. The study showed that digital transformation of enterprises is significantly positively correlated with commercial credit financing. The mechanism of action found that digital transformation achieves the enhancement effect of commercial credit financing by reducing enterprise information risk and optimizing enterprise operating efficiency. Therefore, digital transformation can be seen as a signaling mechanism to reduce information asymmetry and enhance market trust.

In terms of research on the impact of digital transformation, multiple scholars have found that digital transformation promotes financial stability. Yang Changhui and Zhang Keli (2016) found that the degree of interest rate marketization is significantly negatively correlated with the cost of debt financing for private enterprises, while accounting conservatism is significantly positively correlated with the cost of debt financing for private enterprises. The improvement of accounting

conservatism can alleviate the increase in debt financing costs caused by the increase in interest rate marketization. Firstly, the digital transformation of procurement, production, operation, and sales by enterprises usually revolves around improving resource allocation efficiency, especially the application of digital technology in supply chain and financial management, which can improve the efficiency of capital utilization, reduce costs and energy consumption. On the other hand, digital transformation can improve the financial and internal control mechanisms of enterprises, optimize the company's cash flow situation, and better repay debts on time, which reduces the risk for creditors and correspondingly lowers the cost of debt financing. Digital transformation means that companies pay more attention to financial management and risk control, and this positive attitude will also increase the trust of creditors in the company. The stable financial performance of the company will enhance its reputation and credibility in the market, and creditors will have more confidence in it and be willing to provide debt financing to it at a lower cost. Based on the above analysis, this article proposes the core research hypothesis:

Assuming all other conditions remain constant, the digital transformation of small and medium-sized enterprises will significantly reduce their debt financing costs.

3. Research Design

3.1. Sample Selection and Data Sources

This article takes small and medium-sized enterprises listed on the Shanghai and Shenzhen stock exchanges from 2009 to 2023 as the original sample, and performs the following preprocessing steps on these data: 1) excludes listed companies in the ST, * ST, insurance, and financial industries; 2) excludes data with abnormal or missing values in the financial data of enterprises; 3) to control for the influence of extreme values, this article shrinks all continuous variables at the top and bottom 1% level. After screening, 13502 valid observations were finally determined for 1940 small and medium-sized enterprises over a period of 13 years. The data used were all sourced from the CSMAR database and processed using Excel. Empirical analysis and testing were conducted using Stata18 software.

3.2. Variable Definition

1) The dependent variable: The explanatory variable of this article is the cost of corporate debt financing (COD), and scholars at home and abroad have various methods for selecting indicators of corporate debt financing costs. Li & Liu (2009) calculated the ratio of financial expenses to total liabilities at the end of the period, where financial expenses include "interest expenses", "handling fees", and "other financial expenses" in the notes to the financial statements. Considering the availability of data and the comprehensiveness of measuring debt costs, this article chooses the indicator of financial expenses that includes interest expenses. The

larger the COD, the higher the cost of corporate debt financing.

$$\text{COD} = \frac{\text{Interest expense}}{\text{Total liabilities at the end of the period}} \tag{1.1}$$

$$\text{COD} = \frac{\text{financial expenses}}{\text{Total liabilities at the end of the period}} \tag{1.2}$$

2) Core explanatory variable: The specific measurement indicator is the degree of digital transformation of the enterprise. This article refers to the approach of Zhang et al. (2021), and the proportion of intangible assets related to digital transformation in the year-end intangible asset details disclosed in the financial report notes to the total intangible assets. When the detailed items of intangible assets include a series of keywords related to digital technology such as "software", "network", "client", "intelligent management platform", and this patent, define the detailed item as "digital technology intangible assets" and calculate its proportion in the current year's intangible assets.

$$\text{Digital} = \frac{\text{Intangible assets of digital technology}}{\text{Total value of intangible assets at the end of the period}} \tag{1.3}$$

3) Control variables: This article controls a series of enterprise characteristic variables that may affect the cost of corporate debt financing in the model. Mainly includes: executive shareholding ratio (Mshare), measured by the ratio of executive shareholding to the number of outstanding shares multiplied by 100%; The asset liability ratio (Lev) is measured as the ratio of total liabilities to total assets multiplied by 100%; Profitability (ROA), measured by the return on assets of the enterprise, i.e. net profit/total assets; Revenue growth rate (Growth), measured by the ratio of revenue growth to the total revenue of the previous year multiplied by 100%; The company size is measured by the natural logarithm of the total assets of the enterprise. Enterprise Age, measured from the year of registration to 2023; Top five holdings of shares (TOP5); Proportion of Independent Directors (Indep); Inventory proportion (INV).

4) Mediating variable: Media attention (Press). The logarithm of the number of positive media reports on enterprises, including both print media and online media, is taken after adding 1. The more positive media reports on enterprises, the higher the level of media attention; Corporate financial stability (Z-Score). Following the approach of Wu Yili et al., this article uses the Z-Score index to measure the financial risk of enterprises. The larger the Z-Score index, the smaller the financial risk of the enterprise and the better its financial stability.

3.3. Model Construction

To study the impact of digital transformation of small and medium-sized enterprises on their debt financing costs, which is the core hypothesis, this article refers to the research of Wu Fei et al. and Wang et al., and constructs an econometric model as follows:

$$COD_{it} = \alpha_0 + \alpha_1 Digital_{i,t} + \sum \alpha CVs + \mu_j + \delta_t + \varepsilon_{it} \quad (1.4)$$

Among them, the dependent variable in the regression is the cost of corporate debt financing (COD), the core explanatory variable is the degree of digital transformation of the enterprise, and CVs are the aforementioned control variables; ε is the random error term of the model. All regressions in this article use bidirectional fixed effects, while fixing individuals and years to absorb differences between individuals and different years, and controlling for primary industry classification to absorb fixed effects of industries as much as possible.

4. Empirical Results and Analysis

4.1. Descriptive Statistical Analysis

Table 1 presents the descriptive statistical results. In this set of data, each variable contains approximately 13,502 observations, demonstrating the distribution characteristics of various indicators of the enterprise. Including the mean, standard deviation, maximum, minimum, and median of the dependent variable, explanatory variable, and each control variable. The results show that the average debt financing cost for COD small and medium-sized enterprises is 1.5%, with a maximum value of 5.6%, indicating that there are indeed financing constraints in small and medium-sized enterprises, and their debt costs are relatively high. The level of digital transformation of digital enterprises adopts the proportion of intangible assets related to digital transformation in the annual report, with an average value of 0.139 and a maximum value of 1, indicating that there is a large gap between enterprises. Some enterprises are in the early stage of transformation, while others are high-tech enterprises themselves, but the overall level of digitalization is not high, indicating that the level of digital transformation of small and medium-sized enterprises in China needs to be improved. From the table, it can be seen that the variation range of each data is not significantly different, and there is no need to adjust the unit level.

Table 1. Descriptive statistics of variables.

Variable	N	Mean	SD	Min	Median	Max
COD	13,502	0.015	0.013	0.000	0.013	0.056
Digital	13,502	0.139	0.232	0.000	0.045	1.000
Size	13,503	21.969	0.997	18.349	21.859	27.299
Lev	13,503	0.389	0.192	0.055	0.376	0.887
ROA	13,503	0.032	0.089	−1.324	0.037	0.953
INV	13,336	0.126	0.092	0.000	0.109	0.506
Growth	13,502	0.146	0.354	−0.534	0.098	1.951
Top5	13,503	0.498	0.147	0.069	0.495	0.935

Continued

Age	13,503	2.885	0.329	1.792	2.944	3.526
Mshare	13,432	18.363	19.123	0.000	12.231	66.654
Indep	13,501	37.918	5.354	33.330	36.360	57.140

Note: The data are derived from the results of Stata processing.

4.2. Correlation Analysis

Correlation analysis is used to evaluate the strength and direction of the linear relationship between two variables, which helps us understand the interactions between variables and explore the causal relationship between variables in depth. The correlation between COD and explanatory variables as well as most control variables is strong, with most correlation coefficients close to zero, possibly due to the small range of COD changes in the sample. The correlation coefficient between Digital and COD is −0.107, indicating a slight negative correlation, suggesting that digital transformation may slightly reduce the cost of corporate debt financing. The correlation between Digital and other control variables is relatively low, all below 0.06, indicating that there is a high probability of no multicollinearity problem and it will not affect the stability of the model and the coefficient estimation of explanatory variables (Table 2).

Table 2. Correlation analysis.

Variable	COD	Digital	Size	Lev	ROA	INV	Growth	Top5	Age	Mshare	Indep
COD	1.000										
Digital	−0.107***	1.000									
Size	0.051***	−0.032***	1.000								
Lev	0.023***	−0.037***	0.413***	1.000							
ROA	0.003	−0.005	0.090***	−0.337***	1.000						
INV	0.005	0.004	0.042***	0.225***	−0.015*	1.000					
Growth	−0.021**	−0.014	0.099***	0.024***	0.326***	0.039***	1.000				
Top5	−0.026***	−0.041***	0.017*	−0.089***	0.233***	0.061***	0.087***	1.000			
Age	−0.025***	0.056***	0.090***	0.070***	−0.085***	−0.053***	−0.103***	−0.177***	1.000		
Mshare	−0.078***	0.002	−0.200***	−0.217***	0.135***	−0.018**	0.047***	0.176***	−0.104***	1.000	
Indep	−0.028***	0.033***	−0.059***	−0.013	−0.027***	0.008	−0.013	0.003	0.041***	0.068***	1.000

Note: *, **, ***respectively indicate significant levels at 5%, 1%, and 0.1%.

The VIF value was used to test for multicollinearity in the model, and the results showed that the variance inflation factor values of all variables were less than 10 (VIF < 10), indicating that the model does not have multicollinearity issues. The results are shown in Table 3:

Table 3. VIF value.

Variable	VIF	1/VIF
Lev	1.60	0.624
ROA	1.45	0.690
Size	1.35	0.739
Growth	1.16	0.863
Top5	1.11	0.899
Mshare	1.11	0.901
INV	1.07	0.931
Age	1.06	0.941
Indep	1.01	0.989

Note: The data are derived from the results of Stata processing.

4.3. Analysis of Benchmark Regression Results

Table 4 reports the core test results of the relationship between digital transformation of small and medium-sized enterprises and debt financing costs. In benchmark regression, this article adopts a progressive regression strategy. Model (1) only controlled for individual, time, and industry fixed effects, and its regression results showed a significant negative correlation between the degree of digital transformation (Digital) of small and medium-sized enterprises and the cost of corporate debt financing (COD) at the 0.1% level, with a coefficient of −0.00259 and a T-value of −4.52, $P < 0.001$. In Model (2), the control variable set was included on the original basis, and the correlation regression coefficient was −0.00261, with significance remaining unchanged (T-value of −4.53). This indicates that as the digitalization level of small and medium-sized enterprises (SMEs) increases, their debt financing costs (COD) will decrease, and the core assumption holds true.

Table 4. Empirical regression results.

	(1)	(2)
VARIABLES	COD	COD
Digital	−0.00259***	−0.00261***
	(−4.52)	(−4.53)
Size		0.00027
		(1.07)
Lev		0.00260**
		(2.49)
ROA		0.00145
		(1.00)
INV		0.00749***
		(3.68)
Growth		−0.00019
		(−0.64)

Continued

Top5		−0.00899*** (−5.56)
Age		0.00545*** (3.12)
Mshare		−0.00002** (−2.11)
Indep		−0.00004 (−1.32)
Constant	0.01137*** (3.57)	−0.00225 (−0.30)
R-squared	0.019	0.027
Year Effect	YES	YES
Industry Effect	YES	YES
Fixed Effect	YES	YES

Note: 1) The data are derived from the results of Stata processing, 2) *, **, ***respectively indicate significant levels at 5%, 1%, and 0.1%, 3) The t-value is in parentheses, the same below.

4.4. Robustness Test

To verify the reliability of the empirical regression results in this article, a robustness test was conducted. Considering the issue of heteroscedasticity caused by a large amount of data, cluster robust standard error regression analysis was used again. Considering that there may be some omitted variables in the model, three control variables were added. Considering the impact of the epidemic period, the sample interval was changed for testing.

This study grouped according to industry clustering, and the robust standard error of clustering can correct the problem of underestimation of standard errors caused by neglecting the correlation between error terms, enhancing the reliability of regression results. The regression results are shown in (2), with a digital transformation coefficient value of −0.00261, which is the same as the benchmark regression coefficient and significant at the 0.1% level, consistent with the benchmark regression. This indicates that the robustness test has been passed under stricter clustering robustness standard errors.

Considering that there may be some omitted variables in the model, this article adds three control variables on the basis of the original model, namely, the capital occupation of major shareholders (Occupation), whether the enterprise is losing money (Loss), and the proportion of institutional investors (INST). Comparing the regression results (3) with the baseline regression results (1), it can be seen that the digital transformation coefficient is −0.00257, which is slightly higher than the coefficient −0.00261 in the baseline regression results (1). This indicates that the newly added control variables have absorbed some of the influence of explanatory variables, and the significance level remains unchanged at 0.1%,

indicating that the results are significant. Even if there are some omitted variables, the impact is not significant, ensuring the robustness of the model.

During the epidemic, due to increased market uncertainty, investors' aversion to risk has increased, leading to an expansion of credit spreads on corporate bonds, which means that the cost of corporate financing has risen. At the same time, the epidemic has led to a tightening of market liquidity, and investors and financial institutions are more inclined to hold cash, reducing the demand for corporate bonds and other financing tools, thereby increasing the difficulty and cost of financing for enterprises. Due to the impact of the epidemic, many companies have experienced a decline in revenue and even had their credit ratings downgraded, increasing the risk of default in the future, which directly affects their financing costs. Considering the impact of the epidemic and the characteristics of its aftermath, this article excluded the enterprise sample data from 2020 and 2021. The regression results are shown in (4), with a digital transformation coefficient of −0.00294, which is smaller than the coefficient value of −0.00261 for the entire sample. This indicates that after excluding specific years, the role of digital transformation in reducing debt financing costs for small and medium-sized enterprises has been strengthened. Regression result (4) is still significant at the 0.1% level, indicating the robustness of the results (Table 5).

Table 5. Robust test.

	(1)	(2)	(3)	(4)
VARIABLES	COD	COD	COD	COD
Digital	−0.00261***	−0.00261***	−0.00257***	−0.00294***
	(−4.53)	(−3.09)	(−4.46)	(−4.47)
Size	0.00027	0.00027	0.00036	0.00029
	(1.07)	(0.63)	(1.38)	(0.98)
Lev	0.00260**	0.00260*	0.00232**	0.00214*
	(2.49)	(1.70)	(2.20)	(1.76)
ROA	0.00145	0.00145	0.00403**	0.00126
	(1.00)	(0.91)	(2.35)	(0.70)
INV	0.00749***	0.00749**	0.00787***	0.00811***
	(3.68)	(2.54)	(3.85)	(3.33)
Growth	−0.00019	−0.00019	−0.00016	0.00009
	(−0.64)	(−0.61)	(−0.56)	(0.25)
Top5	−0.00899***	−0.00899***	−0.00814***	−0.00950***
	(−5.56)	(−3.55)	(−4.14)	(−5.08)
Age	0.00545***	0.00545	0.00560***	0.00481**
	(3.12)	(1.62)	(3.20)	(2.41)
Mshare	−0.00002**	−0.00002	−0.00003*	−0.00004***
	(−2.11)	(−1.28)	(−1.90)	(−2.62)
Indep	−0.00004	−0.00004	−0.00004	−0.00003
	(−1.32)	(−1.08)	(−1.35)	(−0.79)

Continued

Occupy			0.00460 (1.02)	
Loss			0.00096*** (2.62)	
INST			−0.00067 (−0.50)	
Constant	−0.00225 (−0.30)	−0.00225 (−0.18)	−0.00489 (−0.65)	0.00042 (0.05)
R-squared	0.027	0.027	0.027	0.031
Year Effect	YES	YES	YES	YES
Industry Effect	YES	YES	YES	YES
Fixed Effect	YES	YES	YES	YES
cluster	NO	YES	NO	NO

Note: 1) The data are derived from the results of Stata processing, 2) *, **, ***respectively indicate significant levels at 5%, 1%, and 0.1%.

4.5. Heterogeneity Analysis

Different corporate attributes may have varying effects on the impact of digital transformation on debt financing costs. This study will conduct grouped regression on the entire sample based on the property rights attributes of the enterprise, the region to which the enterprise belongs, and whether the industry in which the enterprise operates is regulated.

1) Nature of Enterprise Equity

This article uses the nature of corporate equity for group regression, where SOE = 1 represents state-owned enterprises and SOE = 0 represents non-state-owned enterprises. According to the models M (1) - M (3) in Table 6, the regression coefficient for state-owned enterprise grouping is −0.00449, which is also significant at 0.1%. For non-state-owned enterprise grouping regression, the coefficient value is −0.0021, and the significance level remains unchanged compared to the benchmark group. Comparison shows that the absolute value of the group coefficient for state-owned enterprises is larger than that of the entire sample, while the absolute value of the group coefficient for non-state-owned enterprises is smaller than that of the entire sample, indicating that digital transformation has a better effect on reducing debt financing costs in state-owned small and medium-sized enterprises. Mainly because they usually enjoy government policy support and credit endorsement, which enhances their credit rating in the capital market and reduces financing risks.

Table 6. Heterogeneity test of corporate equity nature.

Classification criteria	M (1) full sample	M (2) state-owned	M (3) non-state-owned
VARIABLES	COD	COD	COD
Digital	−0.00261*** (−4.53)	−0.00449*** (−3.12)	−0.00215*** (−3.42)

Continued

Size	0.00027 (1.07)	0.00043 (0.62)	0.00024 (0.85)
Lev	0.00260** (2.49)	0.00662** (2.54)	0.00142 (1.23)
ROA	0.00145 (1.00)	−0.00267 (−0.62)	0.00168 (1.10)
INV	0.00749*** (3.68)	0.01239*** (3.09)	0.00488** (2.00)
Growth	−0.00019 (−0.64)	0.00026 (0.39)	−0.00022 (−0.66)
Top5	−0.00899*** (−5.56)	−0.01465*** (−3.76)	−0.00715*** (−3.93)
Age	0.00545*** (3.12)	0.00920** (2.24)	0.00471** (2.42)
Mshare	−0.00002** (−2.11)	0.00000 (0.07)	−0.00003** (−2.15)
Indep	−0.00004 (−1.32)	−0.00009 (−1.32)	−0.00002 (−0.67)
Constant	−0.00225 (−0.30)	0.00768 (0.37)	−0.00055 (−0.07)
R-squared	0.027	0.058	0.023
Number of stkcd	1,922	316	1,606
Year Effect	YES	YES	YES
Industry Effect	YES	YES	YES
Fixed Effect	YES	YES	YES
F	7.383	3.660	5.347

Note: 1) The data are derived from the results of Stata processing, 2) *, **, ***respectively indicate significant levels at 5%, 1%, and 0.1%.

2) Location of the enterprise (Table 7)

Table 7. National and regional divisions.

Region	Province and City
Eastern	Beijing, Tianjin, Hebei, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong, Hainan, Liaoning, Jilin, Heilongjiang
Central	Shanxi, Anhui, Jiangxi, Henan, Hubei, Hunan
Western	Inner Mongolia, Guangxi, Chongqing, Sichuan, Guizhou, Yunnan, Xizang, Shaanxi, Gansu, Qinghai, Ningxia, Xinjiang

Note: Data from the National Bureau of Statistics of China.

This article uses the region where the enterprise is located for group regression, where the enterprise is located in the eastern region with Area = 2, the central region with Area = 1, and the western region with Area = 0. Table 8 shows models M (1) and M (4) - M (6). The regression coefficient for the eastern region group

is −0.00185, and the results are also significant at the 0.1% level. The regression coefficient for the central region group is −0.00603, and the significance level remains unchanged compared to the baseline group. However, the regression coefficient for the western region group is −0.00290, which is not significant at the 5% level. This indicates that digital transformation of small and medium-sized enterprises in the central and eastern regions is more conducive to reducing their debt financing costs. This is due to the relatively developed economic foundation, well-developed infrastructure, abundant talent resources, mature financial markets, and active policy support from the government in these regions. These factors can jointly promote the technological upgrading and operational efficiency improvement of enterprises during digital transformation, enhance their market competitiveness and credit status, and thus enjoy lower interest rates and more favorable financing conditions when financing.

Table 8. Heterogeneity test of enterprise area.

Classification criteria	M (1) Full sample	M (4) Eastern region	M (5) Central region	M (6) Western region
VARIABLES	COD	COD	COD	COD
Digital	−0.00261*** (−4.53)	−0.00185*** (−2.74)	−0.00603*** (−4.29)	−0.00290 (−1.56)
Size	0.00027 (1.07)	0.00018 (0.60)	0.00115 (1.64)	0.00014 (0.16)
Lev	0.00260** (2.49)	0.00322*** (2.71)	−0.00413 (−1.45)	0.00513 (1.35)
ROA	0.00145 (1.00)	0.00275* (1.71)	−0.00890** (−2.18)	0.00234 (0.38)
INV	0.00749*** (3.68)	0.00389* (1.68)	0.02218*** (4.12)	0.01522* (1.88)
Growth	−0.00019 (−0.64)	−0.00050 (−1.44)	0.00075 (1.06)	0.00083 (0.88)
Top5	−0.00899*** (−5.56)	−0.01014*** (−5.41)	−0.01451*** (−3.38)	0.00362 (0.65)
Age	0.00545*** (3.12)	0.00475** (2.46)	0.00697 (1.36)	0.02004*** (2.61)
Mshare	−0.00002** (−2.11)	−0.00004*** (−2.84)	0.00003 (0.88)	0.00004 (0.80)
Indep	−0.00004 (−1.32)	−0.00001 (−0.43)	−0.00013* (−1.87)	−0.00006 (−0.55)
Constant	−0.00225 (−0.30)	0.00531 (0.61)	−0.02065 (−1.04)	−0.06063** (−2.29)
R-squared	0.027	0.028	0.057	0.047
Number of stkcd	1922	1485	269	168
Year Effect	YES	YES	YES	YES

Continued

Industry Effect	YES	YES	YES	YES
Fixed Effect	YES	YES	YES	YES
F	7.383	5.915	3.053	1.460

Note: 1) The data are derived from the results of Stata processing, 2) *, **, ***respectively indicate significant levels at 5%, 1%, and 0.1%.

3) Is the enterprise a regulated industry (Table 9)

Table 9. Regulated industries in China's national economy.

Code	Industry	Code	Industry
B	Mining	C32	Nonferrous metal smelting and rolling processing industry
C25	Petroleum, coal, and other fuel processing industries	C33	Metal products industry
C26	Chemical raw material and chemical product manufacturing industry	D	Electricity, heat, gas and water production and supply
C28	Chemical fiber manufacturing industry	G	Transportation, storage and postal services
C29	Rubber and plastic products industry	I	Information transmission, software and information technology services
C30	Nonmetallic mineral products industry	K	real estate
C31	Black metal smelting and rolling processing industry	R	Culture, sports and entertainment

Note: Data from the National Bureau of Statistics of China.

Table 10 shows models M (1), M (9) - M (10), with a regression coefficient of −0.00423 for small and medium-sized enterprises in regulated industries. The results are also significant at 0.1%, and the absolute value of the coefficient is larger than that of the benchmark group. The regression coefficient value for small and medium-sized enterprises in unregulated industries is −0.00204, and the significance level remains unchanged compared to the benchmark group. The absolute value of the coefficient is smaller than that of the benchmark group. Analysis shows that compared to small and medium-sized enterprises in unregulated industries, digital transformation can be more effective in reducing their debt financing costs. Enterprises in regulated industries typically receive stricter regulation and higher public attention. Digital transformation can significantly improve the operational transparency and efficiency of these enterprises, thereby enhancing the confidence of regulatory agencies and investors. In addition, companies in

regulated industries often need to comply with more regulations and standards, and digital transformation can help them more effectively comply with these regulations and reduce compliance risks.

Table 10. Heterogeneity test of regulated industry.

Classification criteria	M (1) Full sample	M (9) regulated industry	M (10) Non regulated industries
VARIABLES	COD	COD	COD
Digital	−0.00261*** (−4.53)	−0.00423*** (−4.07)	−0.00204*** (−2.93)
Size	0.00027 (1.07)	−0.00002 (−0.05)	0.00058* (1.78)
Lev	0.00260** (2.49)	0.00129 (0.71)	0.00235* (1.78)
ROA	0.00145 (1.00)	−0.00141 (−0.58)	0.00284 (1.56)
INV	0.00749*** (3.68)	0.00429 (1.04)	0.00759*** (3.17)
Growth	−0.00019 (−0.64)	−0.00012 (−0.24)	−0.00024 (−0.67)
Top5	−0.00899*** (−5.56)	−0.00739** (−2.47)	−0.00995*** (−4.90)
Age	0.00545*** (3.12)	0.01118*** (3.43)	0.00416* (1.93)
Mshare	−0.00002** (−2.11)	−0.00006*** (−2.76)	−0.00001 (−0.39)
Indep	−0.00004 (−1.32)	−0.00001 (−0.14)	−0.00005 (−1.63)
Constant	−0.00225 (−0.30)	−0.00818 (−0.57)	−0.00510 (−0.56)
R-squared	0.027	0.033	0.026
Number of stkcd	1922	607	1403
Year Effect	YES	YES	YES
Industry Effect	YES	YES	YES
Fixed Effect	YES	YES	YES
F	7.383	3.957	6.049

Note: 1) The data are derived from the results of Stata processing, 2) *, **, ***respectively indicate significant levels at 5%, 1%, and 0.1%.

4.6. Analysis of Mediating Effects

1) Media attention

In this article, the measurement of "media attention" is based on the number of positive reports on the company's offline and online media, which are

logarithmically processed. Column (1) in Table 11 shows negative and highly significant baseline regression coefficients for fixed individuals, years, and industries with control variables added, indicating that digital transformation can significantly reduce the debt financing costs of small and medium-sized enterprises. In column (2) of Table 11, the digital transformation index (digital) is regressed against media attention (press) with a coefficient of 0.13290, which is significant at the 0.1% level. The regression coefficient is positive and highly significant, indicating that promoting digital transformation in small and medium-sized enterprises can significantly increase their media attention. In column (3) of Table 11, the digital transformation index and the mediator variable media attention were included in the model for regression analysis of debt financing costs. It was found that the media attention coefficient was −0.00025, which was significant at the 5% level, indicating that media attention can reduce debt financing costs. At the same time, the coefficient of the digital transformation index was −0.0025, which was smaller in absolute value compared to the absence of the mediator variable, but still significant at the 0.1% level, indicating that the reduction of debt financing costs by digital transformation is partially mediated by media attention. Therefore, media attention has a partial mediating effect.

Table 11. Mediating effect of media attention.

	(1)	(2)	(3)
VARIABLES	COD	Press	COD
Digital	−0.00261***	0.13290***	−0.00258***
	(−4.53)	(3.50)	(−4.47)
Press			−0.00025*
			(−1.73)
Size	0.00027	0.00977	0.00028
	(1.07)	(0.58)	(1.07)
Lev	0.00260**	0.00292	0.00260**
	(2.49)	(0.04)	(2.49)
ROA	0.00145	0.23673**	0.00150
	(1.00)	(2.49)	(1.04)
INV	0.00749***	−0.24399*	0.00743***
	(3.68)	(−1.82)	(3.65)
Growth	−0.00019	0.00785	−0.00019
	(−0.64)	(0.41)	(−0.64)
Top5	−0.00899***	0.06423	−0.00897***
	(−5.56)	(0.60)	(−5.55)
Age	0.00545***	−0.02388	0.00544***
	(3.12)	(−0.21)	(3.12)
Mshare	−0.00002**	−0.00066	−0.00002**
	(−2.11)	(−0.86)	(−2.12)
Indep	−0.00004	0.00033	−0.00004
	(−1.32)	(0.18)	(−1.32)

Continued

Constant	−0.00225 (−0.30)	3.67051*** (7.48)	−0.00135 (−0.18)
R-squared	0.027	0.234	0.027
Number of stkcd	1922	1922	1922
Year Effect	YES	YES	YES
Industry Effect	YES	YES	YES
Fixed Effect	YES	YES	YES
F	7.383	82.26	7.282

Note: 1) The data are derived from the results of Stata processing, 2) *, **, ***respectively indicate significant levels at 5%, 1%, and 0.1%.

2) Corporate financial stability

The measurement method for "enterprise financial stability" in this article adopts the Z-Score index. Column (1) in Table 12 shows negative and highly significant baseline regression coefficients for fixed individuals, years, and industries with control variables added, indicating that digital transformation can significantly reduce the debt financing costs of small and medium-sized enterprises. In column (2) of Table 12, the digital transformation index (Digital) is regressed against media attention (Z-Score), with a coefficient of 1.56912 and significant at the 0.1% level, indicating a positive and highly significant regression coefficient. This suggests that promoting digital transformation in small and medium-sized enterprises can significantly improve their financial stability. In column (3) of Table 12, the digital transformation index and the mediating variable financial stability were included in the model for regression analysis of debt financing costs. It was found that the financial stability coefficient was −0.00017, which was significant at the 0.1% level, indicating that financial stability can reduce debt financing costs. At the same time, the coefficient of the digital transformation index was -0.00234, which was smaller in absolute value compared to the absence of the mediating variable, but still significant at the 0.1% level, indicating that the reduction of debt financing costs by digital transformation is partially mediated by financial stability. Therefore, financial stability has a partial mediating effect.

Table 12. Mediating effect of financial stability.

	(1)	(2)	(3)
VARIABLES	COD	Z-score	COD
Digital	−0.00261*** (−4.53)	1.56912*** (3.94)	−0.00234*** (−4.09)
Z-Score			−0.00017*** (−12.63)
Size	0.00027 (1.07)	−0.25729 (−1.45)	0.00023 (0.90)

Continued

Lev	0.00260** (2.49)	0.40551 (0.56)	0.00267** (2.57)
ROA	0.00145 (1.00)	−0.52028 (−0.52)	0.00136 (0.95)
INV	0.00749*** (3.68)	−1.56557 (−1.11)	0.00722*** (3.57)
Growth	−0.00019 (−0.64)	−0.13735 (−0.68)	−0.00021 (−0.73)
Top5	−0.00899*** (−5.56)	0.89662 (0.80)	−0.00883*** (−5.51)
Age	0.00545*** (3.12)	−1.39351 (−1.15)	0.00521*** (3.00)
Mshare	−0.00002** (−2.11)	−0.00262 (−0.32)	−0.00003** (−2.16)
Indep	−0.00004 (−1.32)	−0.00549 (−0.28)	−0.00004 (−1.36)
Constant	−0.00225 (−0.30)	14.73002*** (2.86)	0.00026 (0.04)
R-squared	0.027	0.054	0.040
Number of stkcd	1,922	1,922	1,922
Year Effect	YES	YES	YES
Industry Effect	YES	YES	YES
Fixed Effect	YES	YES	YES
F	7.383	15.47	11.02

Note: 1) The data are derived from the results of Stata processing, 2) *, **, ***respectively indicate significant levels at 5%, 1%, and 0.1%.

5. Research Conclusion and Implications

This article takes Chinese small and medium-sized enterprise listed companies from 2009 to 2023 as the research object, and uses a two-way fixed effects model to empirically test the impact of digital transformation of small and medium-sized enterprises on their debt financing costs and its mechanism. The research results show that digital transformation of small and medium-sized enterprises will significantly reduce their debt financing costs. The higher the degree of digital transformation of enterprises, the lower their debt financing costs; After conducting robustness tests by increasing clustering robustness standard errors, adding control variables, and changing sample intervals, the regression results remained consistent with the baseline regression results; The digital transformation of enterprises can reduce the cost of debt financing for small and medium-sized enterprises by increasing media attention to the enterprise and reducing financial risks; The role of digital transformation in reducing debt financing costs for enterprises is more significant in non-state-owned enterprises, enterprises in regulated

industries, and small and medium-sized enterprises in the central and eastern regions.

The following suggestions are proposed for this: 1) Small and medium-sized enterprises should continue to promote digital transformation. At present, the digital transformation of Chinese enterprises is still in its infancy, and the level of digitalization is generally low. Enterprises should implement the government's policies on promoting digital transformation, increase investment in digital transformation, regard digital transformation as the direction of high-quality development for enterprises, fully empower various aspects of enterprise management with digital technology, and continuously improve the level of enterprise digitalization. 2) Finance should support the digital transformation of small and medium-sized enterprises. Enterprises and financial institutions can use digital transformation as a lever to reduce financing costs, solve financing difficulties and high financing costs. Financial institutions should closely monitor the new business models and financing needs brought about by digital transformation, deeply participate in the process of enterprise digital transformation and business model reshaping, innovate financing models in intelligent production supply chain reconstruction and business platform construction, and reduce enterprise borrowing costs while controlling their own risks. 3) The government should provide appropriate policy support to small and medium-sized enterprises. Compared with large enterprises, small and medium-sized enterprises have relatively scarce funds and various resources, and digital transformation of enterprises requires a large amount of resource investment, making it even more necessary to achieve "overtaking on the bend" through digital transformation. For example, the government supports digital transformation by formulating policies and regulations, providing financial subsidies, building digital infrastructure, and training talents. The government also supports enterprise digital transformation through various means, aiming to promote sustained and healthy economic development and enhance national industrial competitiveness.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

References

Chen, H. W., & Zhou, Z. S. (2014). Internal Control Quality and Corporate Debt Financing Costs. *Nankai Management Review, 17,* 103-111.

He, D., & Zhu, J. J. (2006). Equity Separation, Private Benefits of Control Rights, and Financing Costs for Controlling Shareholders. *Accounting Research, No. 5,* 50-57, 96.

Huang, R., Lai, X. B., Zhao, D. N. et al. (2021). Can Digital Finance Alleviate Corporate Financing Difficulties: Utility Identification, Feature Mechanism, and Regulatory Evaluation. *Chinese Economic Issues, No. 1,* 52-66.

Huang, W. Y., & Wang, Y. H. (2023). Does LPR Alleviate the Debt Financing Constraints of Small and Medium-Sized Enterprises under High-Quality Development. *Contemporary Economy, 40,* 94-103.

Li, G. Z., & Liu, L. (2009). Debt Financing Costs and Discrimination against Private Credit. *Financial Research, No. 12,* 137-150.

Li, Q. Y., Li, Y., Zhang, Y. N. et al. (2023). Information Spillover Effects of Enterprise Digital Transformation: Empirical Evidence from the Perspective of Supply Chain. *China Industrial Economy, No. 7,* 142-159.

Liu, H., Zhang, J. R., & Zhou, J. (2016). Litigation Risk, Legal Environment, and Corporate Debt Financing Costs. *Nankai Management Review, 19,* 16-27.

Nie, X. H., Jiang, P., Zheng, X. J. et al. (2021). Research on Digital Finance and Regional Technological Innovation Level. *Financial Research, No. 3,* 132-150.

Shu, W., & Chen, Y. (2024). Research on Digital Transformation and Enterprise Commercial Credit Financing Behavior. *Accounting Research, No. 1,* 79-93.

Wu, F., Hu, H. Z., Lin, H. Y. et al. (2021). Digital Transformation of Enterprises and Capital Market Performance: Empirical Evidence from Stock Liquidity. *Managing the World, 37,* 130-144.

Yang, C. H., & Zhang, K. L. (2016). Research on the Cost of Debt Financing for Private Enterprises: Based on the Dual Perspectives of Interest Rate Marketization and Accounting Conservatism. *Chinese Management Science, 24,* 405-412.

Zhang, T., & Bai, Y. H. (2016). Research on the Impact of Information Disclosure Quality of Small and Medium sized Enterprises on Debt Financing Constraints. *Journal of Shandong University of Finance and Economics, 28,* 109-117.

Zhang, Y. S., Li, X. B., & Xing, M. Q. (2021). Enterprise Digital Transformation and Audit Pricing. *Audit Research, No. 3,* 62-71.

Zhao, L. F., Sun, T., & Chen, S. P. (2019). Has Political Affiliation Eased the Debt Financing Constraints of Small and Medium-Sized Enterprises—Discussion on the Information Value Added Role of Social Audit. *Financial Communication, No. 30,* 125-128.

Zhao, Y., & Tan, Z. B. (2012). E-Commerce, Bank Credit, and SME Financing: A Theoretical Model Based on Information Economics. *Economic Research, 47,* 99-112.

Zhou, K. T., Ma, Z. M., & Wu, L. S. (2017). Academic Experience of Executives and the Cost of Corporate Debt Financing. *Economic Research, 52,* 169-183.