

# Corporate Digital Transformation and Debt Financing Costs: An Empirical Study Based on Intangible Assets Measurement

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**Abstract.** In today's digital economy, digital transformation has become a crucial strategy for businesses, with its effects at the corporate level attracting considerable interest from both scholars and industry professionals. This study uses a classification of intangible assets to develop a new measure of corporate digital transformation, based on annual report data from China's A-share listed companies between 2011 and 2023. It then empirically investigates how digital transformation influences corporate debt financing costs. The results show a significant negative relationship between digital transformation—measured by the share of digital intangible assets—and debt financing costs. In other words, greater investment in digital transformation corresponds to lower costs of debt financing. These findings offer important guidance for companies aiming to reduce expenses and provide a theoretical basis for corporate transformation and development.

**Keywords:** Digital Transformation, Debt Financing.

## 1. Introduction

Fueled by the global surge in the digital economy, corporate digital transformation has become a key strategy for reshaping industrial ecosystems and gaining competitive advantages. Since China's 14th Five-Year Plan explicitly advocated for "leveraging digital transformation to comprehensively change production methods," the annual growth rate of digital investments by enterprises in manufacturing and other sectors has surpassed 20% [1]. At the same time, digital transformation has become an unavoidable path for small and medium-sized enterprises (SMEs) aiming to grow in the post-pandemic era [2]. Increasingly, companies are undertaking various forms of digital transformation, highlighting its historical inevitability and significantly changing corporate financing environments and capital structures.

From a theoretical standpoint, digital transformation can lower corporate debt financing costs by reducing information asymmetry, decreasing agency costs, sending positive signals to the market, and enhancing supply chain risk management. Prior studies also show that digital transformation reduces debt financing costs through improved information flow and stronger corporate governance [3]. Specifically for SMEs, digital transformation cuts debt financing costs by easing information asymmetry and boosting internal management quality [4]. However, current research on measuring digital transformation has notable shortcomings: most empirical studies depend on a single textual analysis method that counts the frequency of digital-related keywords in annual reports. These measures fail to capture the depth of technology application (i.e., whether it is superficial), cannot incorporate actual operational realities, are hard to compare across firms, and are inevitably biased by the rhetorical style of annual reports. This paper argues that tangible, verifiable assets created through digital transformation better reflect genuine corporate investments and the core capabilities or tools developed. A higher share of such assets generally indicates that more resources have been concretely invested in digital assets. Nan attempts to develop a measurement method that combines textual analysis with financial statement data to assess "substantive outcomes" rather than mere "conceptual hype," thereby reducing the "noise" found in purely textual approaches [5].

Additional contributions of this paper include: (1) demonstrating from the perspective of intangible asset investment that its fundamental value lies in reducing information asymmetry, lowering default risk, improving financial health, and shaping creditor expectations, which together enhance corporate financing conditions; and (2) proposing a new "technology-enabled" approach to overcoming

financing challenges by focusing on corporate technological investments. These findings carry important practical implications for improving the efficiency of financial resource allocation and fostering high-quality economic development driven by digital technology.

## 2. Literature Review and Research Hypotheses

Multiple studies have shown that corporate digital transformation positively impacts firm performance by lowering operational costs, boosting innovation, and consistently enhancing both operational and financial metrics [6-8]. Companies undergoing digital transformation also gain signaling advantages. For example, firms that receive national-level digital certifications (such as "Lighthouse Factory") signal technological leadership to the market, while those situated in key national strategic areas (like those involved in the "East Data West Computing" initiative) benefit from policy-driven synergies supporting their digital investments. Moreover, technologies such as smart contracts help limit counterparties' default risks, thereby reducing contingent liabilities from external disputes [9]. Consequently, creditors are more confident that digitally transforming firms can sustain stable growth and demonstrate resilience to risks, which significantly improves creditor expectations.

While some research points to the persistence of the "IT productivity paradox" in digital transformation—where only certain firms benefit, especially when increased management costs and efficiency losses offset gains in sales activities, notably in firms lacking adequate management capabilities—government subsidies and support for digitalization can alleviate these challenges [10,11]. Additionally, as financial institutions continue to advance their digital transformation on the credit supply side, alongside the marketization of data assets and the growing standardization of data asset recognition and accounting, the associated management costs and creditor risk premiums are expected to decrease. Therefore, firms engaged in digital transformation are likely to experience lower debt financing costs. Based on this reasoning, the following hypothesis is proposed:

H1: There is a significant negative relationship between the extent of corporate digital transformation and the cost of debt financing.

## 3. Research Design

### 3.1. Sample and Data

This study selects data from China's A-share listed companies between 2011 and 2023 as the research sample to examine the relationship between corporate digitalization and debt financing costs. The indicators for corporate digitalization level and debt financing costs are derived from textual analysis and calculations of annual reports of listed companies, with annual report data sourced from the CSMAR database. To ensure research accuracy, the data were further screened according to the following criteria: (1) Following conventional practice, financial firms were excluded due to inconsistencies in their primary business activities and accounting/reporting systems compared to industrial enterprises; (2) ST firms and those delisted during the period were removed; (3) Observations from initial public offerings (IPOs) were omitted. The final sample comprises 46,405 observations.

### 3.2. Model

To investigate how digital transformation affects debt financing costs in listed companies, the following research model is designed:

$$Cost_{it} = \alpha_0 + \alpha_1 Digital_{it} + \alpha_2 CONTROL_{it} + \gamma_i + \vartheta_t + \varepsilon_{it} \quad (1)$$

Where  $\gamma_i$  represents industry fixed effects,  $\vartheta_t$  denotes time fixed effects, and  $\varepsilon_{it}$  is the random error term. *CONTROL* refers to a set of control variables.

### 3.3. Variables

**Dependent Variable.** Based on the study by Caputo et al., the cost of debt is calculated as the ratio of a company's financial expenses to its total liabilities at the end of the period. This variable represents the debt financing cost for firm  $i$  in year  $t$  [12].

**Independent Variable.** Following the method of Nan et al., digital transformation-related items are identified from detailed intangible assets disclosed in the notes of corporate financial reports [5]. These include terms such as "network," "software," "smart platform," and "management system," which are categorized as intangible assets associated with digital transformation. The indicator is computed as the proportion of the year-end total of these relevant intangible assets to the total intangible assets, serving as a proxy for the firm's level of digitalization. To address potential endogeneity and account for the delayed effect of digital transformation on corporate strategic decisions, this explanatory variable is lagged by one period.

This method directly captures actual capitalized and identifiable intangible investments linked to digital transformation. Examples include purchased software, customized smart platforms, and developed network systems, which represent genuine financial investments by firms that comply with accounting standards for capitalization. These better reflect real digital transformation activities that constitute assets.

The specific variables and their definitions are presented in the table below:

**Table 1.** Variable Definitions

Variable	Meaning	Definition
Cost	Debt financing cost	Ratio of financial expenses to total liabilities at period-end
Digital	Degree of digital transformation	Ratio of year-end relevant intangible assets to total intangible assets
SIZE	Firm size	Natural logarithm of total assets
LEV	Asset-liability ratio	Total liabilities / total assets
ROA	Return on total assets	Net profit / total assets
TobinQ	Tobin's Q ratio	Market value of the firm / replacement cost of the firm
Growth	Operating revenue growth rate	Current year operating revenue / previous year operating revenue - 1
Cashflow	Cash flow ratio	Net cash flow from operating activities / total assets
ATO	Total asset turnover ratio	Operating revenue / average total assets
Top5	Top five shareholders' holdings	Combined shareholding of top five shareholders / total shares

## 4. Empirical Results

### 4.1. Descriptive Statistics

The descriptive statistics indicate that the dataset includes 46,405 observations. The average value of the dependent variable, debt financing cost (Cost), is 0, with a standard deviation of 0.05. The lowest value is -2.45, which suggests that some companies earn more interest income than expenses, possibly due to holding substantial cash or deposits. The main independent variable, the degree of digital transformation (Digital), has an average value of 0.12 (standard deviation: 0.25), meaning that digital-related intangible assets make up about 12% of total intangible assets on average. However, the large gap between the maximum value (1.11) and the median (0.02) highlights a significant imbalance in digital investment among firms, with most companies still exhibiting low levels of digital transformation. Regarding control variables, the average firm size (Size), measured as the logarithm of total assets, is 22.14, which aligns with typical features of A-share listed companies. The

mean asset-liability ratio (Lev) is 0.42, and the total asset turnover ratio (ATO) is 0.67, both consistent with previous studies [13], indicating that the sample is representative.

**Table 2.** Descriptive Statistics

Variable	N	Mean	SD	Min	p50	Max
Cost	46405	0	0.05	-2.45	0.01	0.95
Digital	46405	0.12	0.25	0	0.02	1.11
ROA	46404	0.04	0.08	-1.86	0.04	1.28
Lev	46405	0.42	0.21	0.01	0.41	1.96
Size	46405	22.14	1.33	17.64	21.94	28.7
TobinQ	46405	2.04	1.83	0.61	1.6	122.19
Growth	46382	3.55	628.92	-1.44	0.1	1.30E+05
Cashflow	46405	0.05	0.08	-1.08	0.05	0.84
ATO	46401	0.67	0.54	-0.05	0.56	12.37
Top5	46405	0.54	0.16	0.01	0.54	0.99

## 4.2. Regression Results

The baseline regression results presented in Table 3 systematically analyze the effect of corporate digital transformation (Digital) on the cost of debt financing (Cost). In column (1), without including any control variables, the coefficient for Digital is -0.0228 and is statistically significant at the 1% level ( $*p* < 0.01$ ). As control variables are gradually introduced, the coefficient in column (3) becomes -0.0194 ( $*p* < 0.01$ ). When year and industry fixed effects are further accounted for in column (4), the coefficient remains significantly negative at -0.00810 ( $*p* < 0.01$ ). This consistent negative association suggests that each one-unit increase in the degree of digital transformation corresponds to an average reduction of 0.008 in debt financing costs, supporting the main hypothesis that "digitalization lowers financing costs." Economically, based on the standardized coefficient in column (4), a one-standard-deviation rise in Digital (0.25) leads to an approximate 0.0016 standard deviation decrease in Cost (calculated as  $0.00810 \times (0.05/0.25)$ ). Although this effect size is modest, it aligns with the gradual impact expected from transformation processes. Among the control variables, the asset-liability ratio (Lev) has a significantly positive coefficient (0.0997,  $*p* < 0.01$ ), consistent with the theory that "higher leverage increases financial risk and credit premiums" [14]. Both firm size (Size) and Tobin's Q (TobinQ) show significantly negative coefficients, indicating that larger scale and better market valuation help alleviate financing constraints. Regarding model performance, the  $R^2$  value rises from 0.011 in column (1) to 0.224 in column (4). Incorporating fixed effects to control for unobserved factors reduces the absolute magnitude of the Digital coefficient, suggesting that including control variables and fixed effects helps address omitted variable bias and improves the model's specification validity.

**Table 3.** Regression results

	(1)	(2)	(3)	(4)
VARIABLES	Cost	Cost	Cost	Cost
Digital	-0.0228***	-0.0108***	-0.0194***	-0.00810***
	(-22.78)	(-7.19)	(-20.95)	(-5.20)
ROA			-0.0114***	-0.00618
			(-3.13)	(-1.00)
Lev			0.100***	0.0997***
			(71.97)	(16.98)
Size			-0.00169***	-0.00172***
			(-8.11)	(-3.01)
TobinQ			-0.000452***	-0.000581***
			(-3.45)	(-3.31)
Growth			-1.04e-07	-6.98e-08*
			(-0.29)	(-1.80)
Cashflow			0.0152***	-0.000958
			(4.58)	(-0.29)
ATO			0.00366***	0.00394***
			(8.41)	(3.31)
Top5			-0.0236***	-0.0260***
			(-15.57)	(-11.56)
Constant	0.00642***	0.00501***	0.0125***	0.0139
	(23.33)	(7.21)	(2.84)	(1.29)
Observations	46,405	46,397	46,381	46,373
R-squared	0.011	0.096	0.169	0.224
Year Fixed Effects	No	Yes	No	Yes
Industry Fixed Effects	No	Yes	No	Yes

t-statistics in parentheses, \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

### 4.3. Robustness Tests

#### 4.3.1. Extended Variable Window

To further address potential reverse causality, the explanatory variable was lagged by one, two, and three periods, respectively, before rerunning the baseline regression. As shown in Table 4, regardless of whether year and industry fixed effects are controlled, the estimated coefficient  $\alpha_1$  of Digital remains significantly negative, indicating that the baseline conclusion remains robust.

**Table 4.** Extended Variable Window

	(1)	(2)	(3)
VARIABLES	Cost	Cost	Cost
L1_Digital	-0.00940***		
	(-4.93)		
L2_Digital		-0.00845***	
		(-5.66)	
L3_Digital			-0.00629***
			(-3.45)
Controls	Yes	Yes	Yes
Observations	40,184	35,233	30,881
R-squared	0.230	0.222	0.229
Year Fixed Effects	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes

t-statistics in parentheses, \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

### 4.3.2. Replacement of Explained Variable

Debt financing cost was redefined as Cost2, calculated as the ratio of the sum of interest expenses, handling charges, and other financial expenses to total liabilities at the end of the period. The results, shown in Table 5, demonstrate that the coefficient of digital transformation remains significantly negative regardless of whether industry and year fixed effects are incorporated, consistent with the baseline regression results.

**Table 5.** Replacement of Explained Variable

	(1)	(2)
VARIABLES	Cost2	Cost2
Digital	-0.00150**	-0.00810***
	(-22.15)	(-2.36)
Controls	Yes	Yes
Constant	0.0220***	0.0139
	(16.09)	(6.61)
Observations	46,373	46,373
R-squared	0.200	0.224
Year Fixed Effects	No	Yes
Industry Fixed Effects	No	Yes

t-statistics in parentheses, \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

## 5. Conclusion

Using data from China's A-share listed companies between 2011 and 2023, this study introduces an innovative method for classifying intangible assets to identify and measure investments directly linked to digital transformation—such as software, intelligent platforms, and network systems—by analyzing notes in corporate financial statements. It develops a new metric that captures the "real outcomes" rather than the "conceptual hype" of corporate digitalization and empirically investigates how digital transformation affects corporate debt financing costs. The key findings are as follows: Baseline regression results consistently and robustly reveal a significant negative relationship between the extent of corporate digital transformation and debt financing costs. After controlling for important factors like firm size, financial leverage, profitability, growth, cash flow, asset turnover efficiency, and ownership concentration, and including year and industry fixed effects, each one-unit increase in digital transformation corresponds to an average significant decrease of about 0.008 units in corporate debt financing costs. This conclusion is strongly supported by various robustness checks, including extending the lag period of the explanatory variable (lags 1–3) and using alternative methods to measure the dependent variable.

The study's policy recommendations are as follows: Regulators should focus on establishing a comprehensive support system that integrates infrastructure, institutional frameworks, and financial incentives. At the infrastructure level, efforts should accelerate the deployment of new technologies such as 5G networks and industrial internet identifier resolution nodes. Institutionally, guidelines for recognizing and valuing corporate data assets should be issued promptly, alongside improvements to a standardized certification system for digital transformation. On the financial front, targeted subsidized loans should be created to support digital transformation in small and medium-sized enterprises (SMEs), commercial banks should be encouraged to develop tailored financial products, and corporate digital maturity should be incorporated into credit evaluation models.

For companies, debt financing costs result from the dynamic interaction of multiple factors at the micro (firm-specific), meso (governance), and macro (environmental) levels. From a dynamic adjustment perspective, debt costs are state-dependent: the same company faces different risk premiums depending on policy cycles (e.g., monetary easing versus tightening), development stages (e.g., growth versus maturity), and governance quality. This means companies should treat debt

management as an ongoing optimization process rather than a fixed objective. Firms need to move beyond a superficial understanding of technology use and view digital transformation as a means to rebuild strategic capabilities and enhance financial resilience. They should develop transformation roadmaps tailored to their industry characteristics, learning from leading companies that can serve as benchmarks. Simultaneously, they must advance process reengineering and cultivate digital talent to ensure the transformation is coherent and systematic.

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