



# Corporate Digital Transformation, Financing Constraints and Innovation Input

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**Abstract.** In the context of the digital era, the impact of corporate digital transformation on innovation investment has become a focus of attention in academia and the industry. Based on the annual data of A-share listed companies from 2013 to 2023, this paper adopts word frequency statistics to quantify the process of enterprise digital transformation, and applies the SA index to measure the status of enterprise financing constraints. By constructing a multiple regression model, this paper delves into the relationship between corporate digital transformation, financing constraints and innovation investment. It is found that enterprise digital transformation significantly promotes innovation input. In addition, financing constraints play a mediating role between digital transformation and innovation investment. The paper also analyses the heterogeneity of the impact of digital transformation in terms of both firm size and region, and finds that digital transformation promotes innovation input more significantly in eastern regions and among small and medium-sized enterprises. The research in this paper not only enriches the theory related to digital transformation and corporate innovation, but also provides practical guidance for policymakers and corporate managers.

**Keywords:** digital transformation, financing constraints, innovation investment, firm size, regional differences

## 1 Introduction

### 1.1 Background of the Study

Digital transformation is becoming a key part of economic and social development worldwide, with major regions accelerating their digital strategies. According to the White Paper on the Global Digital Economy (2023), the digital economy's value added in 51 countries reached \$41.4 trillion in 2022, growing 7.4% annually and representing 46.1% of GDP. Industrial digitization is the main driver, comprising 85.3% of the digital economy's share. As consumer behavior and needs become more digital, companies are enhancing their competitiveness and innovation through digital transformation to meet market demands.

Innovation investment is crucial for sustainable growth and competitive advantage, closely linked to digital transformation. This transformation broadens innovation opportunities and improves enterprise innovation ability by boosting human capital and information quality<sup>[1]</sup>. Human capital and R&D investments also drive digital innovation and development, speeding up digital transformation<sup>[2]</sup>.

Chinese listed companies face financing constraints, affecting their technological innovation. Alleviating these constraints can increase innovation investment<sup>[3]</sup>. A stable financial market, appropriate policies, and government subsidies can help at a macro level, while suitable financing structures and executive technical backgrounds can alleviate constraints at a micro level<sup>[4]</sup>.

Despite the importance of digital transformation and innovation investment, enterprises face challenges in implementation. This study aims to explore the relationship between digital transformation and innovation investment, providing theoretical and practical guidance for enterprise digital transformation and innovation development.

## 1.2 Research Significance

This research addresses a theoretical void by exploring the link between digital transformation, financing constraints, and their effects on corporate innovation. It enhances understanding through analyses of firm size and regional differences. Practically, it integrates financing constraints into a research framework, clarifying their role in digital transformation and innovation, aiding firms in boosting innovation and stability. The study's policy suggestions offer insights for government action in resource allocation and infrastructure, which are crucial for digital economy growth and helping businesses overcome financing hurdles to compete in the market.

## 1.3 Literature Review

Researchers disagree on the impact of digital transformation on corporate innovation investment. Some believe digital spending might divert funds from physical investment and impede innovation due to its risky and uncertain nature<sup>[5]</sup>. Others argue that digital transformation can reduce uncertainty and optimize resource allocation, thereby promoting innovative R&D. Duan Huayou et al.'s study shows a positive link between digital transformation levels and innovation investment, suggesting higher innovation outputs with greater investment intensity<sup>[6]</sup>. Regarding mechanisms, Bai, F. P. et al. propose that digital transformation can enhance corporate innovation by easing financing constraints and agency problems<sup>[7]</sup>. Li, W. H. et al., from the perspective of innovation networks, find that increased digitalization can boost innovation activities by strengthening corporate innovation networks<sup>[8]</sup>. Hui Shupeng et al.'s analysis of R&D versus non-R&D innovations indicates that digitalization improves innovation investment by increasing R&D staff, with government support amplifying this effect, while marketization level may mitigate the positive impact of digitalization on R&D innovation investment<sup>[9]</sup>.

In examining the relationship between digital transformation and financing constraints, there are two prevailing views. One, based on information asymmetry theory,

suggests that digitalization improves information transmission efficiency and availability, reduces asymmetry between managers and shareholders, and alleviates financing constraints<sup>[10]</sup>. The other view is that digitization optimizes corporate governance, reducing agency problems and thus easing financing constraints<sup>[11]</sup>.

Academic studies indicate progress in understanding the relationship between digital transformation and innovation investment, but further in-depth discussion is needed. While existing studies show that digital transformation enhances innovation investment through various pathways, they lack detailed analysis considering financing constraints as a mediating variable. This study hypothesizes that digital transformation indirectly affects innovation investment through financing constraints, aiming to uncover the complex mechanisms at play. Additionally, the study will analyze the heterogeneous impact of digital transformation from regional and firm size perspectives to provide targeted recommendations for firms with different characteristics.

## 2 Theoretical Analysis and Research Hypothesis

Stakeholder theory suggests that by increasing the positive disclosure of digital transformation in annual reports, firms aim to improve information quality, optimize investment efficiency and firm valuation in order to attract the attention of the capital market<sup>[12]</sup>. This not only enhances stakeholders' confidence in the future development of enterprises, increases capital investment and ensures the stability of R&D capital flow, but also promotes enterprises to strengthen innovative R&D.

Resource dependence theory suggests that in a market economy, resource dependence of organizations on the external environment is inevitable<sup>[13]</sup>. Digital transformation enables firms to efficiently integrate and utilize external information resources, alleviates financing constraints, and has a profound impact on firms' dual innovation capabilities. This paper adopts resource dependence theory as an analytical framework to explore how digital transformation affects firms' financing constraints and innovation investment.

According to the information asymmetry theory, sellers have more information than buyers, leading to market inefficiency. Enterprises can reduce the impact of information asymmetry through digital transformation, provide more transparent and detailed information, help investors make more accurate decisions, and improve the efficiency of capital allocation, as well as improve the efficiency of enterprise information processing and circulation, enhance internal collaboration and production effectiveness, reduce communication costs, promote management innovation, and provide more funds for R&D. Based on the above theoretical analysis, this paper proposes the following research hypotheses:

H1: Enterprise digital transformation positively affects enterprise innovation investment.

H2: Enterprise digital transformation negatively affects enterprise financing constraints.

H3: Enterprises undergoing digital transformation will alleviate financing constraints and enhance enterprise innovation investment.

### 3 Research Design

#### 3.1 Sample Selection and Data Source

The study uses annual data from 2013-2023 for A-share listed companies as its initial sample, excluding \*ST, ST, financial industry, and insolvent companies, as well as those with missing data. To mitigate the influence of outliers, continuous variables are winsorized at the 1% and 99% levels, resulting in 15,596 valid samples. Data is sourced from the CSMAR database and processed using Stata17.0 software for accuracy and efficiency.

#### 3.2 Definition of Main Variables

**Explanatory Variable: Digital Transformation (Digital).** In this paper, we refer to the research methodology of Wu Fei et al.<sup>[14]</sup> to measure the digital transformation of enterprises by counting the frequency of keywords related to digitalisation in annual reports and using the natural logarithm of the sum plus one as an indicator.

**Explained Variable: Innovation Input (RD).** Drawing on the research methodology of Shu-Juan Miao et al.<sup>[15]</sup>, innovation investment is assessed by the ratio of R&D expenditure to operating revenue.

**Mediating Variable: Financing Constraints.** This paper relies on Hadlock et al.<sup>[16]</sup> and uses the SA index formula to assess financing constraints, with a negative SA index indicating more severe constraints.  $SA = -0.737 \times \text{Size} + 0.043 \times \text{Size}^2 - 0.04 \times \text{Age}$  (Where Size is the natural logarithm of total assets, and Age is the establishment duration of the enterprise.)

**Control Variables.** Includes firm size, age, gearing ratio, equity balance, return on net assets, net profit margin, operating income growth rate, return on operating cash flow, auditor's affiliation with Big 4, ownership nature, shareholding concentration, and dual positions to account for potential confounding factors.

#### 3.3 Empirical Model Design

In order to deeply explore the relationship between digital transformation and innovation investment, this paper constructs a fixed industry and time multiple regression model (1), and at the same time draws on Zhonglin Wen's (2004) three-step mediation path method<sup>[17]</sup>, adds models (2) and (3), and empirically examines them using the mediation effect model.

$$\text{Model (1): } RD = \alpha_0 + \alpha_1 \times \text{Digital} + \alpha_2 \times \text{Control} + \Sigma \text{year} + \Sigma \text{ind} + \varepsilon$$

$$\text{Model (2): } SA = \beta_0 + \beta_1 \times \text{Digital} + \beta_2 \times \text{Control} + \Sigma \text{year} + \Sigma \text{ind} + \varepsilon$$

$$\text{Model(3): } RD = \gamma_0 + \gamma_1 \times \text{Digital} + \gamma_2 \times SA + \gamma_3 \times \text{Control} + \Sigma \text{year} + \Sigma \text{ind} + \varepsilon$$

Where  $\alpha_1$ 、 $\alpha_2$ 、 $\beta_1$ 、 $\beta_2$ 、 $\gamma_1$ 、 $\gamma_2$ 、 $\gamma_3$  is the regression coefficient of each variable, *Control* is the control variable, *year* and *ind* denote the year and industry fixed effects,  $\alpha_0$ 、 $\beta_0$ 、 $\gamma_0$  is the constant term, and  $\epsilon$  is the random error term.

## 4 Empirical Analysis

### 4.1 Descriptive Statistics

Table 1 summarizes key findings with RD values ranging 0.03 to 26.88 and a standard deviation of 3.68, indicating substantial variation in innovation investment, potentially due to industry traits, market competition, and firms' technological prowess. The disparity between the mean and median of Digital indicates uneven digital transformation levels among firms. The SA indicator, derived from a formula and converted to an absolute value, shows consistency with a median close to the mean. Other variables' descriptive statistics align with expectations.

**Table 1.** Results of descriptive statistics for the main variables

<i>VarName</i>	Obs	Mean	SD	Min	Median	Max
<i>RD</i>	15596	4.744	4.664	0.030	3.680	26.880
<i>Digital</i>	15596	1.633	1.434	0.000	1.386	6.301
<i>SA</i>	15596	3.858	0.257	3.088	3.859	4.515
<i>Size</i>	15596	22.478	1.310	17.806	22.298	28.615
<i>Lev</i>	15596	0.426	0.191	0.068	0.421	0.867
<i>Age</i>	15596	2.160	0.795	0.000	2.303	3.466
<i>balance</i>	15596	0.739	0.588	0.038	0.578	2.761
<i>Growth</i>	15596	0.268	0.609	-0.637	0.121	3.803
<i>CF</i>	15596	0.051	0.063	-0.122	0.049	0.238
<i>BIG4</i>	15596	0.064	0.245	0.000	0.000	1.000
<i>SOE</i>	15596	0.315	0.465	0.000	0.000	1.000
<i>TOP</i>	15596	0.331	0.143	0.090	0.309	0.722
<i>DUAL</i>	15596	0.287	0.452	0.000	0.000	1.000

### 4.2 Base Regression Analysis

Table 2 summarizes the base regression analysis, with column (1) showing results with industry and year fixed effects, and column (2) adding control variables. In column (1), the positive correlation between Digital and R&D investment is 0.508, significant at the 1.0% level. This positive significance persists in column (2) even after controlling for management variables, confirming that digitalization significantly boosts innovation investment, thus supporting hypothesis H1.

**Table 2.** Benchmark regression results

	(1)	(2)
	RD	RD
Digital	0.508*** (16.526)	0.474*** (16.079)
control variables	No	Yes
Industry Fixed Effects	Control	Control
Year fixed effects	Control	Control
N	15596	15596
Adj. R <sup>2</sup>	0.292	0.361

Note: Robust t-statistics for regression coefficients in parentheses; \*\*\* p<0.01, \*\* p<0.05, \* p<0.1(same table below)

### 4.3 Tests for Mediating Effects

Table 3 reports the results of the mediating mechanism test. In column (2), the coefficient of digital transformation is -0.116, a result that suggests, at the 1.0% significance level, that firms' digitalisation process contributes to reducing their financing constraints. Further, in column (3), the coefficient on the impact of digital transformation on firms' innovation inputs is 0.470, again significant at the 1.0% significance level, while the coefficient on financing constraints is -1.177, also significant at the 1% level. These findings support SA as a mediating variable, confirming the article's hypotheses.

**Table 3.** Results of the mediation effect test

	(1)	(2)	(3)
	RD	Digital	RD
Digital	0.474*** (16.079)		0.470*** (15.964)
SA		-0.116** (-2.558)	-1.177*** (-8.076)
control variables	Yes	Yes	Yes
Industry Fixed Effects	Control	Control	Control
Year fixed effects	Control	Control	Control
N	15596	15596	15596
Adj. R <sup>2</sup>	0.361	0.364	0.363

### 4.4 Robustness Tests

**Instrumental Variables Approach.** Considering that there may be a reverse causality problem between digital transformation and firms' investment in innovation, i.e., firms themselves perform better in terms of innovation, and thus are more inclined to undergo digital transformation in order to further enhance their innovation capability

and efficiency. In order to enhance the persuasiveness of the previous conclusions, this paper applies the two-stage least squares (2SLS) method based on Shu et al. (2024), and selects the cities selected for the 2014 Broadband China Strategy as the instrumental variables for model testing<sup>[18]</sup>. It employs cities chosen for the 2014 Broadband China Strategy as instrumental variables. Table 4 shows that: The first-stage regression indicates a strong correlation with the instrumental variables, with significant non-identification at the 1% level and no weak instruments at the 10% level. The absence of over-identification and the second-stage results validate the robustness of the regression, suggesting that the findings are minimally affected by endogeneity.

**Table 4.** Results of endogeneity test

Variables	Phase I Digital	Phase II RD
IV	0.299*** (6.349)	
Digital		2.859*** (4.466)
control variables	Yes	Yes
Industry Fixed Effects	Control	Control
Year fixed effects	Control	Control
N	15596	15596
Adj. R <sup>2</sup>	0.374	-0.358
Kleibergen-Paap rk LM statistic		39.662***
Kleibergen-Paap rk Wald F statistic	40.308*** (10% maximal IV size: 16.38)	

**Replacement of Explanatory Variables.** This study refers to the existing literature<sup>[19]</sup> and adopts the proportion of R&D expenditure to total assets as a measure of corporate innovation investment. This measure helps to exclude the interference of the scale factor and more directly reflect the extent of enterprises' investment in R&D. The results show that the estimated coefficients of financing constraints are significantly negative, while the coefficients of the variables related to digital transformation remain significantly positive. Therefore the main findings of this study are robust. Due to space limitations, the results are not presented in the text.

**Adjusting the Sample Time Horizon.** In order to eliminate the potential impact of the epidemic on the results of the study, the sample period was shortened to 2013-2019 and the sample size was reduced to 10,285. Compared with the previous analyses, the adjusted sample time span did not lead to significant differences in the regression results, and the results remained consistent. Due to space limitations, the results are not presented in the text.

## 4.5 Heterogeneity Analysis

**Table 5.** Results of heterogeneity test

Variables	(1)Large enterprises	(2)Small and medium enterprises	(3)Eastern region	(4)Western region
	RD	RD	RD	RD
Digital	0.309*** (9.561)	0.619*** (15.279)	0.498*** (17.145)	0.361*** (5.958)
control variables	Yes	Yes	Yes	Yes
Industry Fixed Effects	Control	Control	Control	Control
Year fixed effects	Control	Control	Control	Control
N	7801	7795	12607	2989
Adj. R <sup>2</sup>	0.350	0.327	0.365	0.329
seemingly uncorrelated test	chi <sup>2</sup> ( 1)=28.88 Prob >chi <sup>2</sup> ( 1)=0.0000		chi <sup>2</sup> ( 1)=3.30 Prob >chi <sup>2</sup> ( 1)=0.0692	

**Size Heterogeneity.** The study assesses firm size using the natural logarithm of total assets and divides firms into large and SMEs based on the median for regression analysis. Table 5 columns (1) and (2) show that digital transformation boosts innovation investment across all sizes, with a stronger effect in SMEs. The SUEST test indicates a significant difference in the impact of digital transformation on SMEs at the 1% confidence level.

**Regional Heterogeneity.** Firms are divided into Western and Eastern regions for regional heterogeneity analysis, with results in Table 5 columns (3) and (4). Digital transformation's impact on innovation investment is more pronounced in the Eastern region, significant at the 10% level. This may be due to the Western region's slower digital infrastructure development, limiting digital economy growth, fewer firms undergoing transformation, and higher innovation costs, reducing firms' incentive for innovation.

## 5 Conclusions and Recommendations

### 5.1 Research Conclusion

This paper examines the relationship between the impact of digital transformation on enterprise innovation investment through empirical analysis, and the research results show that: Firstly, enterprise digital transformation has a significant positive impact on innovation investment, indicating that digital transformation can effectively enhance

the innovation capacity of enterprises. Second, financing constraints play a mediating role between digital transformation and innovation investment, indicating that digital transformation indirectly promotes enterprises' innovation investment by alleviating financing constraints. Third, there is heterogeneity in the impact of digital transformation on innovation investment, in which small and medium-sized enterprises and those in the eastern region show a stronger promotion effect.

## 5.2 Recommended Measures

Based on the research findings, here are the policy recommendations to support the digital transformation of SMEs and underdeveloped regions: To bolster SMEs and foster digital advancement in less developed areas, policymakers should focus on enhancing digital infrastructure, which is crucial for bridging the digital divide. Financial incentives, such as tax breaks and subsidies, should be directed towards SMEs to encourage investment in digital initiatives. Improving the financial market environment for SMEs is essential, which can be achieved by reducing financing costs and expanding access to diverse funding options. Additionally, fostering talent development and technological cooperation through educational programs and public-private partnerships can significantly enhance digital capabilities. Encouraging enterprises to build digital capacity and increase R&D spending will further drive innovation and competitiveness. Governments should also consider establishing demonstration projects to showcase successful digital transformations, providing a blueprint for other businesses to follow. These targeted measures can effectively support SMEs and underdeveloped regions in their digital transformation journey, promoting overall economic innovation and growth.

## References

1. Shao-Lin Chen, Bing Hu & Ming Zhang. (2024). How Does Digital Transformation Affect Corporate Technology Innovation? --An empirical study based on dual internal and external perspectives. *Enterprise Economics*(09),48-59.
2. Li, J., Zhao, V. & Wu, Z. Y..(2024). Tax incentives, human capital investment and enterprise digitalization. *Fiscal Research* (05), 40-55.
3. Cheng, X. X. & Liu, Z. H. (2024). Financial Openness, Financing Constraints and Corporate Innovation Investment. *Nankai Economic Research* (02), 64-82.
4. Pan, Hongbo & Yang, Haixia. (2021). Financing constraints and corporate innovation: a literature review. *Finance & Accounting Monthly* (01),30-36.
5. Jin, Y., Wen, W. & He, Y. (2022). The impact of digital transformation on corporate green innovation - Empirical evidence based on listed companies in China's manufacturing industry. *Finance and Trade Research* (07), 69-83.
6. Duan, Huayou, Yang, Xingliu & Dong, Feng. (2023). Digital Transformation, Financing Constraints and Firm Innovation. *Statistics and Decision Making* (05), 164-168.
7. Bai, F. P., Dong, K. Y. & Liu, D. H.. (2023). How Digital Transformation Affects Corporate Technological Innovation - An Empirical Analysis Based on Financing Constraints and Agency Problem Perspectives. *Friends of Accounting* (10), 124-133.

8. Li, W. H., Dong, F. & Li, E. J. (2023). A Study on the Impact of Digitalization Level on Corporate Innovation Activities - Based on the Perspective of Innovation Network. *Journal of Hebei University of Economics and Trade* (05), 36-45.
9. Hui, Shupeng & Wang, Zhuo. (2024). Impact of digitization on innovation investment in high-tech industries - A comparison based on R&D and non-R&D innovations. *Science and Technology Progress and Countermeasures* (22), 80-88.
10. C.D. Tan, X. Zhao, J. Pan & J. Tan. (2022). The value of digital transformation: a perspective based on corporate cash holdings. *Research in Finance and Economics* (03), 64-78.
11. Zhou, Lan & Weng, Yeying. (2023). Corporate digitalisation and financing constraints. *Industrial Technology & Economics* (05), 20-29.
12. Zou, Wei Yu & Wang, Ye. (2022). Digital Transformation and Investment Efficiency of Distribution Enterprises from the Perspective of Heterogeneity. *Journal of Business and Economics* (10), 121-124.
13. Ma Yingxian. (2005). Inter-organizational relationships: A review of studies from a resource dependence perspective. *Management Review* (02), 55-62+64.
14. Wu, F., Hu, H. Z., Lin, H. Y. & Ren, X. Y.. (2021). Corporate digital transformation and capital market performance - Empirical evidence from stock liquidity. *Management World* (07), 130-144+10.
15. Miao, S. J., Xia, M. & Meng, Q. Shun. (2018). A study on the impact of executive incentives on R&D investment - the moderating role of ultimate control. *Industrial Technology & Economics*(01),41-48.
16. Charles J. Hadlock & Joshua R. Pierce.(2010).New Evidence on Measuring Financial Constraints: moving Beyond the KZ Index. *Studies*(5),1909-1940.
17. Zhonglin Wen, Lei Zhang, Jietai Hou & Hongyun Liu. (2004). Mediation effects test procedure and its application. *Journal of Psychology* (05), 614-620.
18. Shu, W. & Chen, Y.. (2024). Digital Transformation and Business Credit Financing Behavior of Enterprises. *Accounting Research*(01),79-93.
19. Changqing Li, Yukun Li & Maoliang Li. (2018). Controlling shareholders' equity pledges and firms' innovation investment. *Financial Research* (07), 143-157.

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