

Impact of the Degree of Digital Transformation on the High Quality of Business Development

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Abstract: China's economic and social growth is significantly impacted by how to support the high-quality development of businesses. Using A-share listed companies in Shanghai and Shenzhen from 2007 to 2022 as the research object, this paper tests the intermediary mechanisms of financing constraints, information asymmetry, and government subsidies, as well as the heterogeneous characteristics of whether the enterprises are state-owned or not, whether they are high-tech or not, and the regionality of the enterprises. It also empirically analyzes the impact of digital transformation on the high-quality development of enterprises. The research concludes that: digitalization can promote the high-quality development of enterprises by reducing financing constraints, increasing government subsidies, and increasing information asymmetry; and the promotional effect of the digital transformation on the high-quality development of enterprises is more significant in the eastern enterprises and state-owned enterprises. The study finds that the digital transformation of enterprises can significantly promote the high-quality development of enterprises, and the conclusion still holds after a series of robustness and endogeneity tests. The results add to the body of knowledge on enterprise high-quality development and digital transformation research. They also offer theoretical pointers for furthering the growth of enterprise high-quality initiatives.

Keywords: digital transformation, high-quality enterprise development, total factor productivity, financing constraints, information asymmetry.

1. Introduction

Ever since the reform and opening up, economic growth has been significantly fueled by company development. The added value of businesses accounted for more than 60% of China's GDP as of 2021, which was estimated by the National Bureau of Statistics to be over 101 trillion yuan. However, issues including resource waste, an illogical industrial structure, and a lack of innovative potential frequently accompany low-quality enterprise development. As a result, the quality of company development is a prerequisite for the quality of economic growth in China. 2022 The State Council's 14th Five-Year Plan for the creation of the Digital Economy, released in January, makes the specific recommendation to "accelerate the digital transformation and upgrading of enterprises," offering a viable route for the creation of high-caliber businesses. This offers a viable route for the superior growth of businesses.

Considerable advancements have been achieved in the field of business digital transformation in the past few years. A growing number of businesses are realizing the value of digital transformation and actively taking action to innovate and change as a result of the quick advancement of technology

and the maturity of digital technology. China's National Bureau of Statistics reports that as of 2020, over 60% of Chinese enterprises were using cloud computing services, and over 50% were implementing big data analytics applications. These statistics indicate that Chinese enterprises have generally adopted digital technologies, including artificial intelligence, cloud computing, and big data analytics. Therefore, is it possible for the digital transformation of businesses to foster the superior growth of businesses? Furthermore, what is the action's mechanism? Previous research has focused on the inverse U-shaped connection between superior company growth and digital transformation[1]. They emphasize how digital transformation may boost risk resistance and innovation momentum, which in turn can support the high-quality growth of businesses[2]. The relationship between technological advancement and company quality improvement has not been thoroughly studied by scholars from a micro perspective. The method and impacts of digitization from a micro perspective on the growth of firm value have not received much attention from academics. It is critical to understand the connection between enterprise digital transformation and enterprise high-quality development in order to help businesses make the necessary transition to excellent prosperity at this pivotal time in the economic expansion of China. This has important theoretical and practical ramifications for encouraging the Chinese marketplace to expand in an excellent way.

This research looks at how digital transformation affects high-quality organizational development and offers suggestions based on panel data from Shanghai and Shenzhen's A-share publicly traded companies between 2007 and 2022. Research has shown that organizations may significantly improve their development processes by implementing digitization. By reducing financial obstacles, boosting government subsidies, and asymmetry in information, digitalization may support the exceptional development of firms. Furthermore, state-owned and eastern firms are more significantly impacted by the digital transformation's impact on the superior growth of businesses.

The following are potential contributions of this paper: ① Examining from a small-scale standpoint how enterprise digital transformation affects the development of enterprise high-quality, integrating financial and non-financial perspectives as well as internal and external enterprise perspectives. Methodically examining the three intermediary mechanisms of government subsidies, information asymmetry, and financing constraints, which enhances earlier research on the macro effects of the shift to digital. ② The paper applies Opportunity Cost Theory (OCT) to examine whether corporate digital transformation lowers the opportunity cost of funding limitations and if this promotes the growth of high-caliber businesses.

2. Literature review

2.1. National Literature Study

Due to China's economy's recent fast growth and the country's widespread use of information technology, More scholars are concentrating on how corporate digitization affects companies' ability to generate excellent goods.

Numerous studies have shown that businesses may dramatically increase their productivity[3] and total factor productivity[4] by implementing a digital transformation. For instance, via fostering the merger of advanced manufacturing and contemporary service sectors, streamlining the human capital structure, and lowering costs through the mechanism, digitization may enhance total factor productivity.[4]

In addition, digitization can bring innovation and differentiated competitive advantages[5] and strengthen businesses' ability to compete in the market, which in turn drives them towards high-quality development.

However, some studies have pointed out that Chinese enterprises face many challenges as part of the procedure of digitization, that includes the existence of shortcomings in key technology support, insufficient coherence of the whole chain of transformation, and a shortage of digital talents[6]. These issues will have an effect on corporate digitization's efficacy and restrict its ability to support the high-caliber growth of businesses.

To give additional effective guidance and assistance with the digital transformation of Chinese enterprises, current domestic research thus focuses on key issues and coping strategies throughout the digital switch cycle, in addition to the impact of digital technology itself on enterprise development.

2.2. Foreign Literature Research

Internationally, the effect of digital change on businesses' superior improvement has garnered major interest as well. Through case studies, cross-country surveys and other methods, scholars in many countries and regions have explored the mechanisms and paths through whereby the overall productivity of factors of firms is impacted by digitization.

It has been shown that using electronic devices may encourage company creation, and jointly promote enterprise innovation through project innovation networks, clan innovation networks, joint innovation networks, etc[7], that encourage the enhancement of business innovation performance, boosting the profitability and competitiveness of businesses.

At the same time, foreign scholars are also concerned about the effects of the digital age on job prospects, industrial structure and economic growth. They discovered that the need for occupational skills and the structure of employment have been profoundly impacted by digital transformation, which has also altered the way businesses are organized and how they produce goods[8]. Digital transformation has accelerated rivalry among multinational companies (MNCs) and encouraged the reshaping and adjustment of the industrial structure[9] in the context of globalization. These developments have had a substantial influence on the state of the world economy.

In conclusion, academics both domestically and internationally concur that one of the critical strategies to raise the caliber of high-quality firm growth is via corporate digital transformation. Future enterprise growth will be more greatly impacted by the digital change process because of the ongoing advancement and deployment of electronic devices.

3. Impact mechanisms and research hypotheses

3.1. Digital transformation and high-quality enterprise development

First, corporate digital change fosters creativity inside the organization, which benefits the high-caliber growth of businesses. Enterprise digital transformation stimulates innovation in products and services, on the one hand[10]. By using digital technology, businesses may provide new goods and services to cater to the evolving demands of their clientele. This inventiveness can enhance the caliber and competitiveness of offerings, hence augmenting the competitiveness of businesses. However, business model innovation is supported by corporate digital transformation[11]. High-quality development is achieved via digital transformation, which modifies conventional business paradigms. For instance, creating new consumer groups and sales channels to provide high-quality development.

Second, digital transformation may enhance the effectiveness of capital allocation, bolster internal controls inside businesses, and encourage the growth of high-caliber businesses[12]. Digital transformation can provide more accurate, real-time and comprehensive data, so enterprises can make more informed capital allocation decisions and optimize the distribution of materials. With the introduction of advanced information systems and technologies, digital transformation enables enterprises to monitor and manage all aspects and processes, and improve the level of internal auditing, risk management and compliance management, thereby achieving sustained superior development.

Third, corporate digital transformation may enhance management effectiveness and organizational capabilities[13], as well as encourage the growth of high-caliber businesses. Businesses can enhance teamwork and efficiency, optimize business processes and project management, and boost the overall capacity and management effectiveness of the organization through organizational change and talent cultivation. This will support the outstanding growth of businesses. As a result, this study presents the following theories.

H1: Digital transformation contributes to high-quality business growth.

3.2. Mechanisms for the impact of digital transformation on high-quality enterprise development

3.2.1. Financing constraints

We use funding limitations as a major mediating variable in our research. Financial limitations might be a significant factor throughout the digital switch cycle because all the way through the digital switch cycle usually requires large investments[14], including technological updates, talent training and system upgrades. Firms constrained by financing constraints may find it difficult to utilize digital technology to the fullest extent possible while limiting their influence on the overall factor production. By analyzing the mediating impact of financing constraints, we are expected to comprehend the substantial consequences of the shift to digital on firms' superior development. Therefore, this essay suggests the following hypotheses.

H2: Digital transformation promotes high-quality enterprise development by reducing the level of financing constraints.

3.2.2. Information asymmetry

The level of data disparity of businesses is another important mediating element that will help us understand how digital transformation influences the excellent growth of enterprises. Digital transformation is usually accompanied by updates in information systems and changes in data management, which may drive firms to reduce the level of information asymmetry[15] This may drive firms to reduce information asymmetry. Reduced information asymmetry can help strengthen partnership, increase investor confidence, create a more favorable development environment for enterprises, and encourage the wholesome, long-term growth of businesses. We may get a deeper knowledge of how total Factor Productivity is impacted by digital revolution in companies by enhancing the degree of information asymmetry by closely analyzing the function of mediation of information asymmetry in digital transformation. Consequently, the following theories are put out in this work.

H3: Digital transformation promotes high-quality business growth by reducing the level of information asymmetry.

3.2.3. Government subsidies

Government Subsidies As the third mediating variable, it plays the role of a bridge between digital change and superior business development of enterprises. Digital transformation of enterprises can increase government subsidies and make better use of government subsidies by improving the convenience of applying for subsidies, improving subsidy management and supervision, and boosting businesses' overall factor productivity in the process.

At the same time, government subsidies may motivate companies to better address the challenges of the digital transformation process, including digital technology innovation constraints[16] and talent training[17] etc. By examining the function of mediation of government subsidies in digital

transformation, we can gain a deeper understanding of how firms can realize the enhancement of productivity among all factors via digitization through government subsidies.

H4: Digital transformation promotes high-quality business development through increased government subsidies.

4. Empirical Strategies

4.1. Sample selection and data sources

In order to empirically examine the effects of digital transformation on the high-quality development of organizations, this article chooses to empirically evaluate the Shanghai and Shenzhen A-share listed companies in China from 2007 to 2022. The following is how the data are handled in this paper: (1) removing the ST and *ST enterprise samples; (2) deleting the samples of financial enterprises. Among them, the digital transformation data resources are sourced from Juchao Information Network, and other variables as well as relevant financial data are from CSMAR database. This research treats every continuous parameter with a 1% shrinkage to remove the impact of high or low values.

4.2. Model construction

This paper integrates a double fixed-effects model of digital transformation and total factor productivity to study the influence of electronically changes on the superior growth of firms. This allows for an improved comprehension of the function and significance of these two critical factors in the operations of Chinese listed companies. This will help provide in-depth insights and insights for corporate strategy formulation, policy making, and future research.

To test the hypothesis, this study constructs the following model:

$$TFP_{i,t} = c_0 + \alpha_0 Digital_{i,t} + \beta_0 \sum control_{i,t} + \sum Year + \sum Industry + \varepsilon_{i,t} \quad (1)$$

Where the model (1) TFP on the left side represents the total factor productivity of the firm; the right side of model (1) c_0 represents the constant terms, the α_0 and β_0 represent the regression coefficients, Digital represents the digital transformation of enterprises, control represents the control variables, and ε represents the residual term. In model (1), the coefficient of the degree of enterprise digital transformation α_0 sign and significance are the focus of this paper, reflecting the impact of enterprise digital transformation (Digital) on enterprise total factor productivity (TFP). If the coefficient of Digital α_0 is significantly positive, it means that digital transformation will increase the total factor productivity of the enterprise, and thus promote the high-quality development of the enterprise.

4.3. Definition of variables

4.3.1. Explained Variables

The rate of increase in real output with the same inputs of the components of production (labor and capital) is known as total factor productivity, or TFP for short. It shows how, in addition to factor inputs, variables like innovation, technical advancement, and effective management contribute to output growth. Increasing the productivity of all factors, on the one hand, enable businesses to grow to a high standard and foster competitiveness and economic growth. Nonetheless, Olley and Pakes were the first to present a two-step consistent estimation method, the main idea of which is to use the firm's current investment as a proxy variable for unexpected productivity spikes, thereby solving the simultaneity bias issue. This approach makes the assumption that businesses base their investment choices on their level of productivity at the moment.

Using Lu Xiaodong et al. as a reference, this article uses the OP technique to calculate the total factor productivity of businesses[18]. The Lu Xiaodong et al. research technique is tested and analyzed using the total factor productivity as assessed by the OP method as a benchmark.

4.3.2. Explanatory variables

Digital Transformation. To gauge the level of digital transformation of listed firms, the frequency of digital terminology in corporate annual reports will be taken out and examined. Digital transformation, as an important strategic initiative, covers the investment and improvement of companies in information technology, digital management and innovation. By mining the digitization vocabulary in annual reports, we will be able to assess the development level of companies in the field of digitization and further explore its correlation with performance and market value. In order to create a system of evaluation indexes for the digital transformation of enterprises, Wu Fei et al.[19] specifically cited the practice of counting 76 digitization-related word frequencies in five dimensions: artificial intelligence technology, big data technology, cloud computing technology, blockchain technology, and the use of digital technology.

4.3.3. Mediating variables

Financing constraints. Gu Leilei and other scholars use FC index as a measure of financing constraints when studying how corporate social responsibility affects corporate financing constraints[20]; Yuan Zeming and other scholars used the FC index as an indicator of financing constraints when studying how digital transformation affects the degree of corporate financing constraints[21]. Financing restriction is shown by the FC index. This research chooses to use the FC index as an explanatory variable to show the level of corporate financing limitations after comprehending the process behind the academics' choice of the index as a gauge of those constraints. The level of enterprise financing restriction increases with the size of the FC index.

Information Asymmetry. The degree of information asymmetry between capital sources and companies is measured in this study using the trading information of individual company shares as a proxy variable, capturing the degree of asymmetry between the knowledge of firm value in the securities market between informed and uninformed traders. Yu et al. [22] calculated liquidity ratio indicator LR and illiquidity ratio indicator ILL, and then calculate the return reversal indicator GAM to describe the stock market liquidity. Finally, principal component analysis is conducted based on the three stock market liquidity indicators to capture their common variation information, that is, the components related to asymmetric information. It is denoted as the information asymmetry index ASY. A larger ASY implies a higher degree of information asymmetry.

Government subsidies. Government subsidies is an important means of direct government regulation of the social economy, mainly in several areas such as ① tax incentives, that is, levy that is refundable, first levy and then return, first levy and then refund, and other subsidies tax subsidies; ② financial subsidies, through the financial allocations of discounts and other forms of subsidies to help listed companies; ③ gratuitous allocation of non-monetary assets, such as the right to use the land in the same way. In this paper, the amount of government subsidies is selected as a mediating variable to measure the connection between superior business growth and digital transformation.

4.3.4. Control variables

Referring to the related literature, the control variables in this paper are as follows: Firm Size (Size), Gearing Ratio (Lev), Cash flow Ratio (Cash flow), Listed year (List Age), Established year Firm Age), Operating Revenue Growth (Growth), Total Asset Growth, Net Profit Growth (Net Profit Growth), Listed year, Established year, Number of Directors (Board), Total Asset Net Profit Ratio

1 (ROA1), Total Asset Net Profit Ratio 2 (ROA2), Management Shareholding Ratio (Mshare), Independent Director Ratio (Indep), Top Shareholder Shareholding Ratio (Top Shareholder Ratio). shareholders (Top1). The paper also controls for year fixed effects and industry fixed effects.

Specific variable definitions and calculations are shown in Table 1.

Table 1: Variables and their calculation

Variable type	Variable name	Variable symbol	Variable calculation
Explanatory variable	Total factor productivity	TFP_OP	OP methodology
Explanatory variable	Digital Transformation	Digital	Textual analysis
Intermediary variable	Financing constraints	FC	FC index
	Information asymmetry	ASY	ASY index
	government subsidy	GS	Value of government subsidies
	Company size	Size	The annual total assets expressed as a natural logarithm
	Gearing	Lev	Year-end total liabilities divided by year-end total assets
	Cash flow ratio	Cash Flow	Net cash flows from operating activities / total assets
	Number of years listed	List Age	$\ln(\text{current year} - \text{year of listing} + 1)$
	Years of Establishment	Firm Age	$\ln(\text{current year} - \text{year of incorporation} + 1)$
	Revenue growth rate	Growth	Current year's operating income / Last year's operating income - 1
	Total asset growth rate	Asset Growth	The sum of all current assets less all past assets minus one
Control variable	Net profit growth rate	Net Profit Growth	Net profit for the year / Net profit for the previous year - 1
	Year of listing	Listed Year	Year of listing
	Year of Establishment	Establishment Year	Establishment Year
	Number of Directors	Board	The board size is calculated using the logarithm of natural numbers.
	Net profit margin for all assets	ROA	Net profit / average balance of total assets
	Ownership of shares by management	Mshare	Directors' and supervisors' shareholdings as a percentage of the total share capital
	Percentage of directors that are independent	Indep	The ratio of directors who are independent to total directors
	Shareholding ratio of the largest shareholder	Top1	The total number of shares and the number of shares owned by the biggest shareholder

4.3.5. Descriptive statistics

Before doing the regression validation, descriptive statistics between the variables are performed. As Table 2 illustrates, the highest amount of enterprise total factor productivity (TFP) is 11.42, The lowest possible number is 2.567, in addition to the normative variability is slightly lower than 1, indicating that the TFP data fluctuates less between enterprises and the data is more accurate. The digital transformation index has a highest score of 547 and a lowest value of 0, suggesting that there is a significant variation in the extent of internet change within organizations, the technological infrastructure of the company level is low, and even some enterprises have not begun to apply digital technology to management, and the realization of digital change is still an important strategic goal for the way businesses will grow in the future. Similarly, through the indicators of the maximum, minimum and mean of other variables, it can be found that different companies possess a large gap between them, which is partly due to different industry characteristics and individual characteristics.

Table 2: Descriptive statistics

	(1)	(2)	(3)	(4)	(5)
	observed value	average value	(statistics) standard deviation	minimum value	maximum values
TFP_OP	33,531	6.653	0.910	2.567	11.42
Digital	33,531	11.40	31.74	0	547
FC	33,531	0.488	0.274	2.40e-05	0.987
ASY	33,531	-0.194	0.471	-7.018	2.827
GS	33,531	4.000e+07	1.859e+08	-1.527e+07	1.601e+10
Size	33,531	22.08	1.939	0	26.45
Lev	33,531	0.433	0.205	0	0.908
Cash Flow	33,531	0.0480	0.0697	-0.223	0.283
List Age	33,531	2.165	0.765	0	3.367
Firm Age	33,531	2.843	0.401	0	3.611
Growth	33,531	0.180	0.417	-0.658	4.024
Asset Growth	33,531	0.171	0.364	-0.383	5.116
Net Profit Growth	33,531	-0.344	3.908	-36.53	23.06
Listed Year	33,531	1,997	131.8	0	2,021
Establishment Year	33,531	1,990	131.2	0	2,015
Board	33,531	2.126	0.245	0	2.708
ROA	33,531	0.0404	0.0649	-0.373	0.257
Mshare	33,531	11.64	18.59	0	70.60
Indep	33,531	37.27	5.905	0	60
Top1	33,531	34.24	14.99	0	75.84

5. Findings and discussion

5.1. Baseline regression analysis

Table 3 shows the regression findings from model (1), which was used to assess the influence of digitization on organizations' excellent development. The regression coefficient of Digital for the enterprise's overall factor productivity is considerable and approaches the significant threshold of 1%. It supports hypothesis H1 by showing that digital conversion has a noteworthy and favorable impact

on businesses' overall factor productivity. This, in turn, has an impact on businesses' superior advancement.

5.2. Robustness Tests

Swap out the explanatory factors. To investigate the potential impact of variations in the enterprise productivity measurement technique on the study's findings, the benchmark regression test is conducted again using the business income of the enterprises in place of overall efficiency of variables. The findings are displayed in Table 3, demonstrating that despite changes in the explanatory variables, the direction of the digital transformation coefficients stays constant and fulfills the importance criterion, demonstrating how the businesses' revenue is being greatly increased by digitization. This suggests that the consequences of the shift to digitalization on enhancing the overall factor productivity of businesses remains constant despite modifications to the data selection that can represent business performance. It also validates the validity of the findings from the benchmark regression discussed in the preceding section.

Table 3: Benchmark regression analysis and Robustness test

	TFP_OP	Revenue
Digital	0.967*** (3.66)	0.003*** (3.37)
Control Variables	YES	YES
_cons	6013.998*** (58.51)	26.752*** (79.84)
<i>N</i>	33514	32640
r2_a	0.518	0.030
F	255.054	26.092

t statistics in brackets

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

5.3. Placebo test

To further confirm the relationship between the consequence of digitalization on businesses' overall factor productivity, a random sample is selected for regression, and the significance of the benchmark regression has no random factor if the regression results conform to a normal distribution. The results are shown in Figure 1, where most of the t-values of the random sample results are located near the zero value, and only the t-values of the no-estimation results are larger than those of the benchmark regression. The benchmark regression coefficient of 0.17 in the unilateral and dual-sided tests is a 0 probability occurrence in the random sample scenario. This suggests that the so-called placebo experiment is valid.

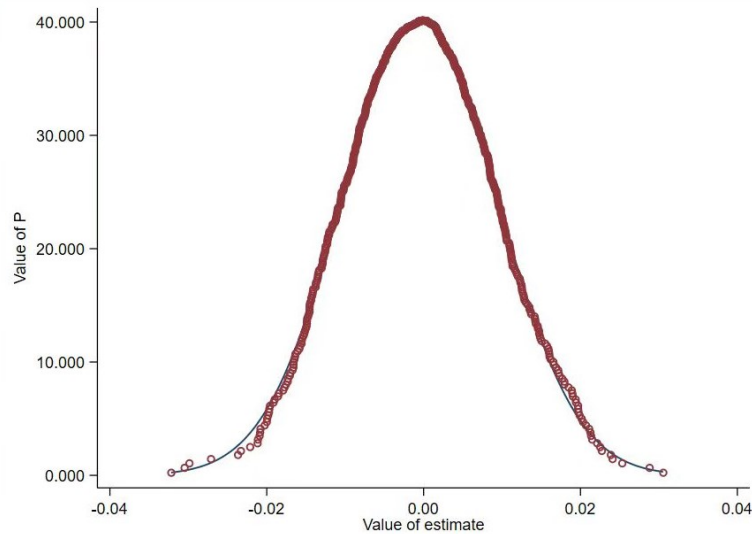


Figure 1: Placebo test t-value plot

5.4. Analysis of intermediary mechanisms

5.4.1. Financing constraints

The test results are shown in Tables 5 and 6's column (1). Table 4's coefficient of digital transformation is negative and reaches 5% significance, proving that digital transformation may lessen an organization's financial restrictions and supporting H2 above. Opportunity Cost Theory suggests that the scarcity and finiteness of resources make it necessary to sacrifice certain opportunities to obtain other opportunities when making choices. Digital transformation increases financing channels and reduces the cost and threshold of financing through crowdfunding, P2P lending and equity crowdfunding through Internet platforms; digital technology can provide more accurate, real-time and traceable data, strengthen investors' understanding and monitoring of the enterprise's financial status and operating conditions, and increase investors' trust in the enterprise, which can help to reduce the financing constraints and financing costs.

5.4.2. Information asymmetry

As shown in column (2) of Table 4, the results of the regression show that digital transformation of firms reduces information asymmetry of enterprises, and H3 is verified. The regression coefficient of digital transformation on information asymmetry is -0.001, which is significant at 1% level. By providing more accurate and comprehensive information, digitalization enables enterprises to better understand the market situation, supply chain conditions, and reduces uncertainty and risk; digitalization helps businesses to manage and analyze a large amount of market data, customer data, and production data, through the analysis of which enterprises can more accurately understand the use of resources, optimize the allocation of resources, improve production process efficiency, reduce resource waste and costs, and increase total factor productivity.

5.4.3. Government subsidies

The regression findings reveal that the digitalization of businesses has a certain driving influence on government subsidies, and H4 is verified. This is seen in column (3) of Table 4 where the regression the digitalization component on government subsidies is positive and substantial. Digitalization

permits businesses to submit subsidy applications more quickly through online platforms, reducing the time and cost of traditional paper applications; digital transformation enables the government to track and monitor subsidy funds with the aid of electronic devices, ensuring the correct use and effectiveness of subsidy funds.

Table 4: Analysis of intermediary mechanisms

	(1) Financing constraints FC	(2) Information asymmetry ASY	(3) Government subsidies GS
Digital	-0.114** (-2.11)	-0.108*** (-5.97)	0.900* (1.90)
Control Variables	YES	YES	YES
_cons	445.558*** (10.04)	-24.554*** (-4.89)	6.5e+04*** (4.27)
<i>N</i>	33514	33514	33514
r ² _a	0.501	0.521	0.159
F	360.304	771.604	25.729

t statistics in brackets
 * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

5.5. Heterogeneity test

5.5.1. Regional heterogeneity

For the purpose of the regression analysis in this study, the sample is split into three groups: East, Central, and West. As Table 5 (1) illustrates, the effect is particularly noteworthy in the eastern area, whereas the advancing effect is not as evident across the western and central areas as it is in columns (2) and (3).

In terms of technical advancement and investment in R&D, digital infrastructure and Internet penetration, industrial agglomeration effects, and talent and skill advantages, the eastern region clearly has an advantage. These factors facilitate the acquisition of resources and support for digital transformation by businesses, thereby increasing total factor productivity. In contrast, the increase in the total factor productivity of firms resulting from digital transformation is limited in the regions to the west and center due to the lagged growth of all the aforementioned variables.

Table 5: Heterogeneity test-1

	(1) Eastern TFP_OP	(2) Central TFP_OP	(3) West TFP_OP
Digital	0.131*** (2.80)	0.181 (1.10)	0.115 (0.91)
Control Variables	YES	YES	YES
_cons	495.015*** (7.53)	589.731*** (3.78)	457.529*** (4.01)
<i>N</i>	5341	843	1062
r ² _a	0.409	0.412	0.484
F	44.643	8.741	17.830

t statistics in brackets
 * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

5.5.2. Heterogeneity in the level of scientific and technological development

The technology level of an enterprise is also an important condition and means for an enterprise to promote digital transformation, and different technology levels of an enterprise may lead to different effects of the enterprise's utilization of digitalization to improve total factor productivity. As presented in Table 6, the results are all significant, but there may be some differences in specific performance.

High-tech enterprises usually focus more on technology application and innovation capability, and digitalization has an even bigger effect on boosting their output; while non-high-tech enterprises focus more on efficiency enhancement and market competitiveness strengthening, and digital transformation can help them achieve these goals. When undergoing digital transformation, businesses should develop suitable digitalization tactics predicated on their business characteristics and requires to achieve maximum productivity gains and competitive advantages.

Table 6: Heterogeneity test-2

	(1) High-tech	(2) Non-high-tech
	TFP_OP	TFP_OP
Digital	0.247*** (3.86)	0.315*** (5.34)
Control Variables	YES	YES
_cons	454.716*** (17.71)	513.899*** (11.75)
<i>N</i>	11253	8261
r2_a	0.529	0.448
F	111.819	39.343

t statistics in brackets

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

5.5.3. Nationalization Heterogeneity

The impact effect of enterprise digital transformation is significant in both SOEs and non-SOEs. However, the specific performance of this enhancement effect may differ in different types of enterprises. As shown in Table 7, the enhancement is more significant in SOEs.

SOEs have resource advantages in digital transformation, such as SOEs possessing more capital, manpower, technology and market channels, etc.; they have state support, including financial subsidies, tax breaks, technical support, etc., which helps SOEs better promote digital transformation. In contrast, non-SOEs are characterized by flexibility and innovation in digital transformation, and face greater competitive pressure in the market. In order to stand out in the competitive market, non-SOEs often need to improve total factor productivity more urgently, and digital transformation has become an effective way for them to achieve this goal.

Table 7: Heterogeneity test-3

	(1) State-owned enterprises	(2) Non-state enterprises
	TFP_OP	TFP_OP
Digital	0.405*** (3.69)	0.111** (2.36)
Control Variables	YES	YES
_cons	626.439*** (4.16)	468.762*** (7.21)

Table 7: (continued).

N	1760	5361
r^2_a	0.368	0.447
F	12.300	55.906

t statistics in brackets
 * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

6. Conclusions and Implications

6.1. Conclusions of the study

The research presented here examines how digitization affects an organization's overall factor productivity using panel data from Shanghai and Shenzhen's A-share listed businesses between 2007 and 2022. Additionally, it analyzes heterogeneity from the viewpoints of nationalization, scientific and technical advancement, and regional heterogeneity. The study comes to the following conclusions: (1) enterprise digital transformation can significantly increase enterprise total factor productivity, which can then encourage the growth of high-quality enterprises; (2) mechanism analysis shows that enterprise digitalization can reduce financing barriers, increase government subsidies, and increase information asymmetry to increase enterprise total factor productivity and promote high-quality development; and (3) heterogeneity analysis shows that the digitization has a more pronounced positive effect on enterprise total factor productivity improvement in the state-owned, eastern enterprises.

6.2. Recommendations

Based on the above findings, this paper makes the following recommendations.

Governmental aspects. First, provide supportive policies. Provide financing support, reduce financing constraints, increase support for science and technology innovation, and provide digital technology and training support. Second, optimize the business environment. Reduce administrative burdens and market access barriers for enterprises, provide a fair and competitive market environment, and incentivize enterprises to participate more actively in digital transformation. Third, strengthen synergy and cooperation. Encourage enterprises to work with other organizations to carry out innovative R&D and technology transformation by establishing cooperation platforms, providing technical support and cooperation incentives.

Enterprises. First, formulate a digital transformation strategy. Include clear goals, steps and timetables, which can help enterprises better plan and implement digital transformation. Second, strengthen innovation capabilities. Continuously introduce and apply advanced digital technologies and tools, explore new business models and products, and gain competitive advantages. Third, strengthen talent development. Establish a professional digital team and provide training and development opportunities to support the digitalization of enterprises.

In summary, through the combined efforts of the government and enterprises, a smooth digitalization can be achieved, further promoting the development of enterprises and economic growth.

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