

Research on the Impact of Digital Finance on the High-Quality Development of Small and Medium-sized Enterprises: Evidence from Listed Companies on the Beijing Stock Exchange

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Abstract. In the era of digital economy, digital finance is an important engine driving the high-quality development of enterprises, and small and medium-sized enterprises solve most of the employment problems in China. Therefore, it is of great significance to discuss the impact of digital finance on the high-quality development of small and medium-sized enterprises. This paper takes small and medium-sized enterprises listed in Beijing Stock Exchange as the research object, and uses two-way fixed effect model to empirically test the influence of digital finance on the high-quality development of small and medium-sized enterprises. The results show that digital finance has a significant promoting effect on the high-quality development of small and medium-sized enterprises. This held true after changing the measure of the explained variable. Mechanism analysis shows that digital finance improves the level of high-quality development by alleviating the "expensive financing" and "difficult financing" of enterprises. Further analysis shows that the impact of digital finance on the high-quality development of small and medium-sized enterprises is heterogeneous among small and medium-sized enterprises of different natures and also heterogeneous among small and medium-sized enterprises in different regions. Finally, this paper puts forward relevant policy suggestions: first, the government needs to further promote the development of digital finance; Second, the government needs to pay attention to the inclusive features of the development of digital finance. Third, the government needs to further improve the inclusive mechanism of digital finance for small and medium-sized enterprises.

Keywords: Small and Medium-sized Enterprises; High-quality Development; Digital Finance; Fixed Effect Model.

1. Introduction

The Outline of the 14th Five-Year Plan for National Economic and Social Development of the People's Republic of China and the Long-Range Objectives Through the Year 2035 proposes to foster new strengths in the digital economy, promote in-depth integration of digital technology with the real economy, and empower the transformation and upgrading of traditional industries. Compared with traditional financial models, the development of digital finance provides small and medium-sized enterprises (SMEs) with diversified, convenient, and targeted financing channels and services, which can effectively address the issues of difficult and costly financing for SMEs. Since SMEs play a key role in solving a large part of China's employment problems, exploring how digital finance empowers the high-quality development of SMEs is of great significance.

Compared with Western countries, China's digital finance started relatively late but has developed rapidly in recent years. Digital finance in the United States can be traced back to as early as 1998, with a history of more than 20 years. The year 2013 is widely recognized by practitioners as the "first year of China's digital finance," which originated from the launch of Yu'e Bao by Alibaba. It is obvious that China's digital finance started late; however, in recent years, the Chinese government has attached great importance to the development of digital finance, leading to remarkable results. On the whole, China's current digital finance development shows a "latecomer" momentum. In addition, due to the different levels of development among regions, there are spatial differences in the development of regional digital finance.

Digital finance promotes the high-quality development of SMEs in multiple aspects, which are reflected in the following:

- 1) Digital finance can improve the convenience of financial services.
- 2) Digital finance can reduce financial transaction costs.
- 3) Digital finance can expand enterprises' financing channels. Through digital financial platforms and tools, enterprises can obtain more financing channels and opportunities, and choose different types of digital financial products and services according to their own needs and risk-bearing capacity.
- 4) The application of digital finance can improve enterprises' risk management capabilities. By adopting digital financial technologies such as big data analysis and risk control models, more accurate management and control of enterprise operations can be achieved, which helps enterprises better manage risks. The improvement of risk management is of great significance to enterprises.
- 5) Digital finance can enhance enterprises' innovation capabilities. The development of digital financial technologies can improve enterprises' innovation capabilities through the application of financial technology and digital transformation, enabling enterprises to better adapt to market demands and changes, thereby achieving continuous innovation and development.

This study focuses on the impact of digital finance on the high-quality development of SMEs, and has important theoretical and practical significance. Firstly, this study focuses on the high-quality development of SMEs, which serves as an important supplement to the literature on how the digital economy affects enterprise development. Secondly, in the current vigorous construction of "Digital China," the research conclusions of this paper also have important guiding significance for enterprises to formulate high-quality development plans and for the government to guide the development direction of digital finance.

2. Research Content and Research Methods

2.1. Research Content

This paper explores how digital finance influences the high-quality development of small and medium-sized enterprises (SMEs). In terms of theoretical research, this paper mainly conducts a relatively systematic review of the literature related to the economic impacts of digital finance, and then conducts logical reasoning based on the literature review to put forward research hypotheses. In terms of empirical research, with reference to relevant literature studies, it conducts descriptive statistical analysis on explanatory variables and explained variables, and carries out comprehensive quantitative research. The explained variable in the empirical research of this paper is the high-quality development level of SMEs, and the explanatory variable is the digital finance index. With reference to relevant research results, control variables at the enterprise level and regional level are introduced. In the empirical regression, a panel fixed model is adopted to study the impact of urban-level digital finance development on the high-quality development level of SMEs. On the basis of the benchmark regression results, this paper also conducts robustness tests, mechanism analysis and heterogeneity analysis, and finally puts forward relevant policy suggestions.

On the basis of the above, the content of this paper can be divided into the following five parts:

The first part is the introduction. First, this part introduces the current situation of the development of digital finance in China, and then expounds the significance of this study. Secondly, it briefly introduces the research methods adopted in this paper. Finally, it analyzes the innovations and shortcomings of this study.

The second part is the literature review and research hypotheses. By reading relevant literature at home and abroad, this paper classifies and sorts out the literature materials, and describes the impacts of digital finance on economic development in the existing research results from both macro and

micro perspectives. Then, based on the existing literature, three research hypotheses of this paper are put forward.

The third part is the empirical design. With reference to the processing methods of existing authoritative literature, this paper selects samples and measures variables for this study, and designs the empirical model of this study.

The fourth part is the empirical results and analysis. This part first conducts descriptive statistical analysis, and then uses the two-way fixed effect model to carry out benchmark regression, robustness tests, mechanism analysis and heterogeneity analysis.

The fifth part is the research conclusions and policy implications of this paper.

2.2. Research Methods

(1) Literature Inductive Method. The literature inductive method refers to the systematic collation, analysis and summary of relevant literature and materials to obtain information and knowledge about a specific research field. This paper systematically retrieves research literature on digital finance and the high-quality development of small and medium-sized enterprises (SMEs), summarizes and sorts out such literature, and establishes the relationship between digital finance and the high-quality development of SMEs through logical deduction.

(2) Empirical Research Method (Two-way Fixed Effect Model). The empirical research method aims to verify or infer conclusions about a specific problem or hypothesis by collecting, analyzing and interpreting actually observed phenomena and data. This research method focuses on the use of quantifiable data and empirical facts for statistical analysis and the establishment of causal relationships. Although this paper has controlled the relevant factors at the enterprise level and regional level that affect the high-quality development level of SMEs, there are still unobservable factors. Therefore, this paper adopts the two-way fixed effect model for empirical analysis. After the benchmark regression model, robustness tests, mechanism analysis and heterogeneity analysis are further conducted.

3. Literature References

3.1. Definition of the Concept of Digital Finance

Leong and Sung (2018) defined digital finance as financial technology, which is a combination of finance and technological innovation. Meanwhile, Schueffel (2016) extracted the definition of financial technology through semantic analysis: digital technology is an emerging financial industry that applies technologies to improve financial activities. Huang Yiping and Huang Zhuo (2018) proposed that digital finance, different from the traditional financial model, refers to the use of digital technologies by financial institutions to carry out traditional financial businesses and develop other new types of financial businesses. This concept is basically similar to the definition of "Internet finance" by ten ministries and commissions including the People's Bank of China, which refers to a new financial model where traditional financial institutions realize fund raising, payment, investment and other businesses with the help of Internet information technology. At the same time, the definition of digital finance includes the use of digital technologies by financial institutions to carry out traditional financial businesses and develop new financial businesses, which is different from the traditional financial model.

3.2. Research on the Impact of Digital Finance Development on Macroeconomic Variables

Since the launch of Yu'e Bao in 2014, digital finance in China has developed rapidly, achieving remarkable results especially in recent years. According to the research of foreign scholars such as Gomber et al. (2018), supported by artificial intelligence, big data technology, Internet technology, distributed technology, and blockchain, digital finance can process massive amounts of data in a low-

cost and low-risk manner, enabling the long-tail groups to overcome various constraints in financial services. The integrated application of these technologies has opened the "rolling shutter doors" and "glass doors" of financial services, creating extensive financial service opportunities for more people. Meanwhile, when reviewing the development of digital finance and looking into the future, Gomber et al. (2017) pointed out that the development of digital finance has changed the mechanism of traditional finance in the past, but its own development relies on technological upgrading, so more attention should also be paid to investment in the technology field. The Chinese government attaches greater importance to the development of digital finance, because digital finance plays an important role in promoting the growth of the real economy and can stimulate the potential driving force for the development of the real economy.

The development of digital finance can promote economic development by stimulating consumption. Through an empirical analysis using data from the China Family Panel Studies, domestic scholars such as Zhang Xun et al. (2021) found that the development of digital finance has significantly increased the income and consumption of Chinese residents by promoting the transformation of the employment structure from agricultural to non-agricultural sectors and increasing wage income and agricultural operating income. Yi Xingjian and Zhou Li (2018) also concluded through tracking data that the development of digital finance has promoted residents' consumption, and the promotion effect is more significant for rural areas, central and western regions, and families in the middle- and low-income groups.

Digital finance is characterized by inclusiveness, openness, and inclusiveness, and also plays a role in promoting the sound development of the real economy. In terms of talent mobility, the research of Ma Shuzhong and Hu Zengxi (2022) shows that digital finance promotes labor mobility by providing employment opportunities and increasing expected income, indicating that the development of digital finance is conducive to the introduction of talents in regions and the efficient allocation of talent resources. In terms of relative poverty, based on the analysis of existing research data, Hu Lian et al. (2021) concluded that the development of digital finance at the current stage has exacerbated relative poverty in urban and rural areas; however, with the popularization of digital tools, the improvement of digital infrastructure, and the increase in education levels, digital finance will help alleviate relative poverty. By testing the relationship between digital finance and the level of regional technological innovation, Nie Xiuhua et al. (2021) found that digital finance significantly improves the level of regional technological innovation by alleviating financing constraints and optimizing the industrial structure.

3.3. Research on the Impact of Digital Finance Development on Microeconomic Variables

Digital finance can affect household income and borrowing. Yin Zhichao et al. (2019) argued that digital finance is conducive to increasing the income level of low-income households; however, due to the still relatively backward development of digital finance in China at present, its promotion effect on low-income households is not significant. Wu Yu et al. (2020) held that the development of digital finance has significantly reduced the possibility of households' private lending, lowered the proportion of lent funds in household finance, and at the same time reduced households' demand for traditional private borrowing. This indicates that the development of digital finance has exerted a substitution effect on household borrowing.

Digital finance can also have an impact on the development of enterprises. First of all, due to its inclusive feature that distinguishes it from traditional finance, digital finance helps guide the more rational flow of funds by saving costs and solving the problem of insufficient information, thus promoting regional entrepreneurship. Domestic scholars such as Xie Xuanli et al. (2018) found through their research that the development of digital finance has a strong effect of encouraging entrepreneurship in provinces with a low urbanization rate and micro-enterprises with a small registered capital. Meanwhile, digital finance has also alleviated the financing difficulties of small and medium-sized enterprises (SMEs) to a certain extent.

The transformation from traditional finance to digital finance also has an important impact on enterprises' investment behavior. By using data related to A-share enterprises and digital finance indexes, Wang Juan and Zhu Weiwei (2020) concluded that the development of digital finance can effectively reduce the level of enterprises' inefficient investment, and this inhibitory effect is more significant for small-scale and high-tech enterprises. By influencing enterprises' investment behavior, the development of digital finance drives enterprises to increase R&D investment, thereby promoting their innovation capabilities. Based on data of listed companies in Shanghai and Shenzhen, Tang Song et al. (2020) found that the development of digital finance indeed has a "structural" driving effect on enterprises' technological innovation. The research of Liu et al. (2022) showed that digital finance promotes enterprises' green innovation by alleviating financing constraints and increasing R&D investment. Furthermore, due to the shortcomings of the traditional financial system in China, such as information asymmetry, resource misallocation, and high costs, the problem of structural resource misallocation has existed for a long time. The research of scholar Ma Shi (2023) indicated that digital finance can alleviate the structural misallocation existing in traditional finance and drive the sustainable growth of SMEs. Therefore, the development of digital finance plays a significant role in promoting the overall healthy competition of Chinese enterprises and advancing their high-quality development.

Digital finance emerged in response to the innovation of Internet technology, and its emergence has also subverted the operation mode and mechanism of traditional finance, forming a digital financial business model that breaks through the traditional credit framework, transcends regional boundaries, and significantly reduces costs. At present, foreign scholars have all drawn positive conclusions from relevant studies on the impact of digital finance on macroeconomic development. Domestic scholars hold the following views: on the one hand, digital finance can stimulate consumer demand and thus drive economic development; on the other hand, due to its characteristics of inclusiveness, openness, and universal benefit, digital finance also plays a certain role in promoting the sound development of the real economy. At the level of microeconomic impact, domestic scholars believe that the development of digital finance has exerted a substitution effect on household borrowing and is conducive to solving the financing difficulties of small and medium-sized enterprises (SMEs). However, relevant research on whether the development of digital finance can truly promote the high-quality development of enterprises still needs to be further explored, and high-quality development can only be achieved under the guidance of the new development concept. Therefore, only by in-depth exploration of these issues and drawing relevant conclusions can the maximum positive role of digital finance be exerted, and real support be provided for the high-quality development of enterprises.

3.4. Research Hypotheses

Owing to the characteristics of low cost, wide coverage, and strong development sustainability, digital finance can break through the traditional credit framework by virtue of Internet technology. This helps alleviate the problems of difficult and costly financing faced by enterprises due to information asymmetry, thereby promoting the high-quality development of enterprises. Awinja and Fatoki (2021) found through a survey of small and medium-sized enterprises (SMEs) in Kenya that the development of digital finance can improve the profitability of SMEs. Xie Xuanli et al. (2018) conducted research by establishing an intermediary mechanism and found that digital finance can significantly promote the innovative development of enterprises. Ran Fang and Tan Yi (2021) found that the coverage breadth, usage depth, and digitalization degree of digital finance all play a role in promoting the total factor productivity of enterprises. At the same time, for China's SMEs, due to the constraints of their development scale and the trouble of information asymmetry, they often find it difficult to obtain external financing. The inclusiveness and low cost of digital finance can just solve this problem, facilitate the external financing of enterprises, and further promote the high-quality development of SMEs. Based on this, the first research hypothesis of this paper is proposed:

H1: Digital finance can promote the high-quality development of SMEs.

Why can digital finance promote the high-quality development of SMEs? Finance has the function of optimizing resource allocation, so that resources can be used with maximum efficiency. However, due to the immaturity of China's current financial market, as well as the low efficiency and high input costs of traditional finance, traditional financial institutions tend to prefer large-scale enterprises due to information costs. This leads to the current predicament where SMEs face great difficulties in obtaining external financing and bear high financing costs. With its inclusiveness and low cost, digital finance can break through the traditional credit framework and solve the problems of information asymmetry, low efficiency of financing channels, and high costs in traditional finance. The research of Ruan Jian et al. (2020) shows that the development of digital finance can significantly reduce the debt financing costs of SMEs. Ren Xiaoyi (2020) found that the higher the regional digital finance index, the lower the financing constraints faced by enterprises. Based on the above analysis, the second and third research hypotheses of this paper are proposed:

H2: Digital finance promotes the high-quality development of SMEs by reducing enterprises' financing costs.

H3: Digital finance promotes the high-quality development of SMEs by alleviating enterprises' financing constraints.

4. Empirical Design

4.1. Sample selection and data sources

4.1.1. Sample selection.

This study selects listed enterprises on the Beijing Stock Exchange (BSE) of China from 2016 to 2021 as the research sample, excluding samples labeled as Special Treatment (ST), samples with abnormal data, and samples with missing annual data. According to the listing systems and rules publicly released by the BSE, the target entities served by the BSE are innovative small and medium-sized enterprises (SMEs). Therefore, in this study, enterprises listed on the BSE are defaulted to be SMEs. The selection of the sample's time span is mainly restricted by two factors: on the one hand, since the BSE was established relatively late, and most of its listed enterprises are private SMEs, there is a lack of sufficient information disclosure. Hence, the starting point of the time span is set at 2016; on the other hand, the measurement indicator for the core explanatory variable is the Peking University Inclusive Finance Index, and currently, this dataset is only updated up to 2021. No updated data was available at the time of writing this paper, so the end point of the sample time span is set at 2021.

4.1.2. Data sources.

The enterprise-level data used in this paper are mainly sourced from the China Stock Market & Accounting Research (CSMAR) Database and the Wind Database, while the regional-level digital finance index data are obtained from the Digital Finance Research Center of Peking University. Regarding the collection of enterprise data, the CSMAR Database and Wind Database cover the data disclosed in the financial reports of enterprises listed on the Beijing Stock Exchange (BSE), and all enterprise-level data used in this paper are derived from these two databases. For a small amount of missing data of some enterprises (such as enterprise registration location and total enterprise assets), manual crawling from the enterprises' financial statements was conducted for supplementation. In addition, the regional-level digital finance index data are from the Digital Finance Research Center of Peking University, which is organized by Guo Feng et al. (2021). Through the above data collection, collation and matching, this paper finally obtains an unbalanced panel dataset of 191 small and medium-sized enterprises (SMEs) listed on China's Beijing Stock Exchange from 2016 to 2021.

4.2. Variable measurement

4.2.1. Explained Variable.

The explained variable in this study is the Total Factor Productivity (TFP) of small and medium-sized enterprises (SMEs). For the measurement of enterprise development quality, this study mainly refers to two previous studies. First, when exploring the relationship between regional business environment and high-quality enterprise development, Shao Chuanlin (2021) proposed that enterprise development quality should prioritize R&D and innovation to drive healthy enterprise development while ensuring financial benefits; based on this definition, he adopted three indicators—enterprise profit per employee, R&D innovation, and return on assets—as measurement metrics. Second, when investigating the integration of industry, university, and research with the high-quality development of small and medium-sized manufacturing enterprises, Wang Yuying and Yuan Changhong (2023) selected Total Factor Productivity (TFP) to measure high-quality enterprise development. Additionally, Wang Yiming (2020) pointed out in his research on high-quality development that "the core of promoting high-quality enterprise development is to improve enterprises' total factor productivity". Therefore, TFP can be regarded as a core indicator for measuring high-quality enterprise development. Drawing on the above literature, this study selects TFP as the indicator for measuring the high-quality development level of SMEs. The difference from existing studies lies in that Wang Yuying and Yuan Changhong (2023) focused on small and medium-sized manufacturing enterprises, while the research objects of this study include not only small and medium-sized manufacturing enterprises but also non-manufacturing enterprises.

This study uses the Levinsohn-Petrin (LP) method to calculate enterprises' TFP. Referring to the processing approach of Giannetti et al. (2015), the TFP of listed enterprises is calculated using Stata 17.0 software. In line with the LP method, the regression model is set as follows:

$$\ln Y_{i,t} = a_0 + a_k \ln K_{i,t} + a_l \ln L_{i,t} + a_m \ln M_{i,t} + \varepsilon_{i,t} \quad (1)$$

Based on the definition of total factor productivity (TFP), the following equation can be derived: $\ln TFP_{i,t} = a_0 + \varepsilon_{i,t}$. Therefore, this study calculates the logarithmic value of enterprises' TFP using the residual values of the aforementioned regression model. For the selection of measurement indicators for the model variables, reference is made to the indicator selection method of Giannetti et al. (2015), as detailed in Table 1 below.

Table 1. Measurement Indicators of the Explained Variable

Explained Variable	Measurement Indicators	Relevant Indicator Data	Data Source
Enterprise Total Factor Productivity (TFP)	Total Enterprise Output (Y)	Ln (Operating Income)	CSMAR
	Capital Input (K)	Ln (Net Fixed Assets)	
	Labor Force (L)	Ln (Number of Employees)	
	Intermediate Input (M)	Ln (Cash Paid for Goods Purchased and Services Received)	

4.2.2. Core explanatory variable.

The core explanatory variable of this paper is the Digital Finance Development Index (DIFI). This index refers to the digital finance development index of the city where the sample enterprise is located, compiled by the Digital Finance Research Center of Peking University, and this paper cites the latest compiled data of the index. The purpose of compiling this index is to describe the development trend of digital inclusive finance in various regions of China. Its compilation method is scientific and reasonable, which ensures high representativeness and objectivity. At present, this index has become

an important tool widely used by many researchers and has been updated to the third phase. The specific indicator adopted in this paper is the Digital Inclusive Finance Composite Index, with a time span of 2016–2021, and the regional scope is precise to the city level. A higher value of this indicator indicates a better development level of digital inclusive finance in the corresponding region. For the data processing of the Digital Finance Development Index, this paper refers to the research of Jiang Hongli and Jiang Pengcheng (2023), and scales down the index by 100 times to eliminate model bias caused by excessively large data dimensions.

4.2.3. Control variable.

By drawing on existing relevant studies, this paper controls for other variables that may affect the high-quality development of small and medium-sized enterprises (SMEs). Shao Chuanlin (2021) argues that the macroeconomic development of a region is one of the factors that may influence the high-quality development of enterprises; therefore, this paper controls for the level of economic development (GDP) at the regional level. In addition, with reference to the research of Li Jialin et al. (2021), this paper introduces a series of enterprise-level control variables, including enterprise age (AGE), capital structure (ABR), shareholder return (ROA), and shareholder shareholding (STOCK). To reduce the difference in data dimensions among the samples, this paper conducts data processing on some control variables with relatively large values. Meanwhile, this paper also incorporates year dummy variables (Year) and industry dummy variables (Ind.). For the definitions of the control variables and their data processing methods, see Table 2.

Table 2. Control Variables Table

Control Variable	Measurement Indicator	Symbol	Selected Data	Data Processing	Data Source
Enterprise-level	Enterprise Age	AGE	Time from registration date to the sample year (Unit: month)	Calculated by subtracting the registration date from the sample year	CSMAR
	Capital Structure	ABR	Asset-Liability Ratio (Unit: %)	Ratio of total liabilities to total assets	
	Shareholder Return	ROA	Return on Assets (Unit: %)	Directly adopted as the indicator value	
	Shareholder Shareholding	STOCK	Shareholding Ratio of the Top 5 Shareholders (Unit: %)	Ratio of the shareholding quantity of the top 5 shareholders to the total share capital	WIND
Regional-level	Regional Economic Development Level	GDP	Real Per Capita GDP of the Enterprise's Location (Unit: 10,000 yuan)	Logarithm taken of the real per capita GDP	China Statistical Yearbook

4.2.4. Mechanism Variables.

Drawing on existing relevant studies, this paper introduces two mechanism variables:

(1) Financing Cost (Cost). Following the research of Xiao Wen and Xue Tianhang (2019), this paper measures financing cost using the financial expense ratio, which is the ratio of a firm's financial expenses to its operating income. (2) Financing Constraints. Also referencing the approach of Xiao Wen and Xue Tianhang (2019), the SA index is adopted to measure financing constraints. The

calculation of this index follows the method proposed by Hadlock and Pierce (2010), and the absolute value of the index is used in the analysis.

4.3. Empirical Models

To test whether there is an impact relationship between the development of digital finance and the high-quality development of small and medium-sized enterprises (SMEs), this paper adopts a fixed effect model, controls for the industry and year fixed effects of the sample, and constructs the following models based on the variables described above:

This paper establishes the following two-way fixed effect model:

$$TFP_{ijt} = \alpha_0 + \alpha_1 DIFI_{it} + \alpha_2 Com_{ijt} + \alpha_3 Area_{it} + \theta_{ind} + \theta_t + \varepsilon_{ijt} \quad (2)$$

Among them, TFP_{ijt} represents the high-quality development index of enterprise j in city I in year t ; $DIFI_{it}$ denotes the digital finance development index of city I in year t ; Com_{ijt} stands for the set of enterprise-level control variables; $Area_{it}$ refers to the regional-level control variables (i.e., the control variables mentioned in Table 2); θ_{ind} is the dummy variable for the industry of enterprise i , which is included to absorb the impact of industry differences on the TFP of small and medium-sized enterprises (SMEs); θ_t is the year dummy variable, intended to control the impact of nationwide policy shocks that change over time on the TFP of SMEs; and ε_{ijt} is the error term.

α_1 represents the impact coefficient of the digital finance development index on the TFP of SMEs. Due to the large differences in the order of magnitude among variables, and since this study focuses on examining the correlation between variables, to reduce the absolute differences in the order of magnitude, the logarithmic transformation is applied to the values of the explanatory variables and some control variables in the regression model.

This model uses the ordinary least squares (OLS) method to estimate parameters and test the relationship between the regional digital finance index and the high-quality development of SMEs.

5. Empirical Results and analysis

5.1. Descriptive Statistical Analysis

Table 3 presents the results of the descriptive statistical analysis of the main variables.

Table 3. Descriptive statistics of the main variables

Variable	Observations	Mean	Median	Standard Deviation	Minimum	Maximum
TFP	764	14.581	14.482	0.672	11.618	17.477
DIFI	764	2.672	2.685	0.318	1.788	3.515
ABR	764	0.366	0.350	0.171	0.033	0.916
ROA	764	0.104	0.097	0.066	-0.288	0.376
AGE	764	15.269	13	10.994	1	32
STOCK	764	80.074	83.970	18.196	27.090	100

Regarding the explained variable, total factor productivity (TFP), there are certain differences across different enterprises, indicating that the high-quality development levels of various enterprises vary. As a proxy variable for measuring an enterprise's output level and profitability, the TFP of the sample enterprises has a maximum value of 17.477 and a minimum value of 11.618. In addition, the digital finance index (DIFI) of the cities where the sample enterprises are located also shows significant regional differences, with a maximum value of 3.515 and a minimum value of 1.788.

From the analysis of enterprise-level control variables, the return on assets (ROA) of the sample enterprises ranges from -0.299 to 0.376, reflecting that there are differences in the profitability of different enterprises in the sample. Moreover, indicators such as equity concentration (STOCK) and

asset-liability ratio (ABR) also vary across enterprises. These differences may be related to factors such as the development stage of the enterprise, industry characteristics, and capital revenue and expenditure conditions in specific years, leading to diversity in the asset allocation strategies of enterprises.

5.2. Benchmark Regression Results

Based on the empirical model (2) introduced in Section 4.3, this paper sequentially adds control variables to the model for stepwise regression, and the results are presented in Table 4. Column (1) only controls for time and industry fixed effects; the results show that the estimated coefficient of DIFI is 0.268 and significant at the 10% level. Column (2) adds the capital structure (ABR) to the specification in Column (1); the estimated coefficient of DIFI rises to 0.287, which is also significant at the 10% level. Columns (3) to (5) further incorporate enterprise-level control variables such as enterprise age (AGE), shareholder return (ROA), and shareholder shareholding (STOCK); the results indicate that the estimated coefficient of DIFI remains positive and significant at the 1% level, with values stable between 0.268 and 0.660.

Columns (1) to (5) only control for enterprise-level variables and do not consider macro-level controls, which may lead to omitted variable bias—i.e., the positive impact of digital finance development on the high-quality development of SMEs could be an illusion caused by omitting regional economic development variables. Therefore, it is necessary to further control for the influence of other macro-level variables on the high-quality development of SMEs. Column (6) adds the economic development level (GDP) of the city where the enterprise is located to the specification in Column (5); the regression results show that the coefficient of DIFI is 0.655, which is positive and still significant at the 1% level.

The empirical results from Columns (1) to (6) in Table 4, obtained by gradually adding control variables, preliminarily indicate that the development of digital finance helps to improve the high-quality development level of SMEs.

Table 4. Stepwise regression results

Model Variable	(1) TFP	(2) TFP	(3) TFP	(4) TFP	(5) TFP	(7) TFP
DIFI	0.268* (1.712)	0.287* (1.770)	0.326** (2.295)	0.354*** (2.589)	0.660*** (5.765)	0.655*** (5.472)
ABR		0.984*** (3.506)	1.503*** (6.860)	1.547*** (7.095)	1.501*** (8.465)	1.506*** (8.445)
ROA			3.080*** (2.922)	3.098*** (3.036)	0.658 (1.617)	0.655 (1.604)
AGE				0.311*** (3.576)	0.171*** (3.024)	0.164*** (2.859)
STOCK					-0.004*** (-2.832)	-0.004*** (-2.925)
GDP						0.005 (0.689)
Year fixed effect	YES	YES	YES	YES	YES	YES
Industry fixed effect	YES	YES	YES	YES	YES	YES
Observed value	831	822	822	822	773	764
R ²	0.211	0.244	0.305	0.327	0.390	0.388

Note: The values in parentheses are t-statistics; ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

5.3. Robustness test

5.3.1. Replacement of the Explained Variable.

To examine the robustness of the conclusions in this paper, the measurement method of the explained variable is replaced to ensure that the aforementioned conclusions are robust. In the analysis of Section 5.2, the explained variable (total factor productivity, TFP) was measured using the Levinsohn-Petrin (LP) method, with reference to the research of Giannetti et al. (2015). Therefore, to rule out the possibility that the empirical conclusions above are caused by measurement bias of the explained variable, a robustness test is conducted by replacing the TFP measurement method—specifically, changing the TFP calculation from the LP method used in the previous study to the Olley-Pakes (OP) method. Different from the literature referenced for the LP method, the OP method for TFP calculation follows the approach of Lu Xiaodong et al. (2012). The details of the data on listed enterprises used for this calculation are presented in Table 5 below:

Table 5. The variable table for measuring TFP by the OP method

Variables Required for Calculation	Variable Symbol	Measurement Indicator
Total Enterprise Output	Y	Enterprise's main business revenue
Capital	K	Enterprise's fixed assets
Labor Force	L	Total number of employees in the enterprise
Intermediate Input	M	Enterprise's cash spent on purchasing goods and services
Investment	I	Enterprise's capital expenditures
Enterprise Age	AGE	Age of the enterprise
Market Exit	EXIT	Whether the enterprise has delisted (dummy variable: 1 = delisted, 0 = not delisted)
Enterprise Nature	SOE	Nature of the enterprise (state-owned, private, foreign-funded)

In the process of calculating TFP using the Olley-Pakes (OP) method, the collected data for the above variables—including total enterprise output, capital, labor, intermediate input, enterprise investment, and age—are subjected to logarithmic transformation. Based on the Cobb-Douglas (C-D) production function, the following regression model is specified:

$$\ln Y_{i,t} = \beta_0 + \beta_K \ln K_{i,t} + \beta_L \ln L_{i,t} + \beta_M \ln M_{i,t} + \beta_n \ln SOE_{i,t} + \beta_U EX_{i,t} + \sum_p \delta_p year_m + \sum_q \varepsilon_q reg_q + \sum_r \gamma_r ind_r + \varepsilon_{i,t} \quad (3)$$

Among them, $\sum_p \delta_p year_m$, $\sum_q \varepsilon_q reg_q$ and $\sum_r \gamma_r ind_r$ represent time fixed effects, regional fixed effects, and industry fixed effects, respectively, and EX is a dummy variable indicating whether the listed enterprise engages in exports. Based on the definition of total factor productivity, it can be derived that: $\ln TFP_{i,t} = \beta_0 + \varepsilon_{i,t}$. Therefore, this paper calculates the logarithmic value of enterprises' TFP using the residual values of the above regression model.

Using the TFP calculated by the OP method, and again adopting the time and industry two-way fixed effect model, the final model from the regression analysis in Section 5.2 is established as the benchmark model, with the measure of the explained variable replaced. The resulting regression shows that the coefficient of DIFI is 0.227, which is positive and significant at the 1% significance level; the specific regression results are presented in Table 6. The results in Column (2) indicate, to a certain extent, that digital finance has a positive promoting effect on the high-quality development of enterprises. Compared with the coefficient of DIFI in Model (1) (0.655), the sign and significance of the DIFI coefficient in Model (2) remain unchanged, still indicating that the development of digital finance has a positive promoting effect on the high-quality development of enterprises. This result rules out the possibility that the above empirical conclusion is caused by the contingency of the explained variable's specification, and also confirms that the empirical results of this paper are robust.

Table 6. The regression result of replacing the measurement method of the explained variable

Model	(1)	(2)
The explained variable	TFP_LP	TFP_OP
DIFI	0.655*** (5.472)	0.227*** (2.926)
Control variable	YES	YES
Year fixed effect	YES	YES
Industry fixed effect	YES	YES
Observed value	764	767
R ²	0.388	0.315

Note: The values in parentheses are t-statistics; ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

5.3.2. Increase regional fixed effects.

To further test the robustness of the conclusions, this paper introduces provincial dummy variables into the original model to control for regional fixed effects. The model after the introduction of these variables is shown as follows:

$$TFP_{ijt} = \alpha_0 + \alpha_1 DIFI_{it} + \alpha_2 Com_{ijt} + \alpha_3 Area_{it} + \theta_{ind} + \theta_t + \theta_{area} + \varepsilon_{ijt} \quad (4)$$

Among them, θ_{area} is the dummy variable for the province where enterprise I is located; it is included to absorb the impact of regional differences on the TFP of SMEs. The specific meanings of the other variables are the same as in Model 2.

The results of the regression analysis based on Model 4 above are shown in Column (2) of Table 7. After adding provincial fixed effects, the coefficient of DIFI is 0.547, which is positive and significant at the 1% significance level. Compared with the coefficient of DIFI in Model (1) (0.655), the sign and significance of the DIFI coefficient in Model (2) remain unchanged, still indicating that the development of digital finance has a positive promoting effect on the high-quality development of enterprises. This result again confirms that the empirical results of this paper are robust.

Table 7. Increase the regression results of regional fixed effects

Model	(1)	(2)
The explained variable	TFP	TFP
DIFI	0.655*** (5.472)	0.547*** (3.123)
Control variable	YES	YES
Year fixed effect	YES	YES
Industry fixed effect	YES	YES
Provincial fixed effect	YES	YES
Observed value	764	735
R ²	0.388	0.424

Note: The values in parentheses are t-statistics; ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

5.3.3. Mechanism inspection.

Based on the regression results obtained from the above analysis, the coefficient of digital finance (DIFI) is significant and consistently positive, and the robustness test has been passed. To further explore the specific channels through which digital finance affects the high-quality development of enterprises, this section conducts a mechanism analysis. Among the analyses, the results of regressing the mechanism variables on the core explanatory variable (digital finance, DIFI) are presented in Table 8 below.

From Column (1) of Table 8, it can be seen that the estimated coefficient of the digital finance variable is negative and passes the significance test at the 5% level, which indicates that digital finance significantly reduces the financing cost of enterprises. Based on the results of the above regression analysis and combined with the conclusions of existing literature on the relationship between financing cost and enterprise development: Li Chong (2015) pointed out that excessively high financing costs would have an inhibitory effect on enterprises' innovation activities; Wu Huabin (2019) argued that the reduction of financing costs is conducive to improving the allocation efficiency of production factors such as labor and capital among enterprises, thereby promoting the high-quality development of enterprises. Furthermore, the reduction of financing costs also means an increase in enterprises' disposable operating funds, which can be further invested in production and R&D. Therefore, digital finance can promote the high-quality development of enterprises by reducing their financing costs.

From Column (2), in the regression of financing constraints on digital finance, the estimated coefficient of the explanatory variable (digital finance) is also negative and passes the significance test at the 1% level. This shows that with the development of digital finance, enterprises' financing constraints will decrease accordingly. Based on the results of the above regression analysis and combined with relevant conclusions in existing literature: according to the research findings of Li Ke and Xu Longbing (2011), enterprises' operating performance will improve with the alleviation of their financing constraints; at the same time, Xie Weimin and Fang Hongxing (2011) believed that the alleviation of financing constraints has a promoting effect on the sound development of enterprises, and this promoting effect is more significant in small-scale enterprises. Based on this conclusion, it can be concluded that the development of digital finance achieves the positive effect of promoting the high-quality development of enterprises by alleviating their financing constraints.

Table 8. Mechanism inspection

Model	(1)	(2)
The explained variable	Financing cost-Cost	Financing constraints-SA
DIFI	-0.012** (-2.252)	-0.267*** (-2.892)
Control variable	YES	YES
Year fixed effect	YES	YES
Industry fixed effect	YES	YES
Observed value	618	747
R ²	0.008	0.512

Note: The values in parentheses are t-statistics; ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

5.4. Heterogeneity analysis

Since the benchmark regression fails to account for the individual characteristics of different enterprises and regional characteristics, a heterogeneity analysis is required to conduct an in-depth study of the impacts of these factors. The benchmark regression can only provide an overall average effect and cannot capture the differences between enterprises or the unique impacts of individual characteristics on the results. By performing a heterogeneity analysis, we can better understand the extent to which heterogeneous factors across different enterprises influence the research object. This type of analysis helps us more accurately assess the effects at the individual and regional levels, thereby providing more comprehensive and accurate research conclusions and decision-making bases. Therefore, this paper will conduct an in-depth examination of the potential heterogeneity caused by relevant characteristics below.

5.4.1. Enterprise heterogeneity.

Considering the characteristics of China's economy and enterprises, digital finance may exert different impacts on the development of enterprises with different ownership types. In this paper,

enterprises are classified into private enterprises, Sino-foreign joint ventures, collective enterprises, local state-owned enterprises (SOEs), and central SOEs based on their equity nature. However, due to the small number of samples of collective enterprises and central SOEs, local SOEs, collective enterprises, and central SOEs are merged into one category, collectively referred to as "state-owned enterprises". Subsequently, the sample is restricted to specific groups for subgroup regression, and the results of the subgroup test are presented in Table 9.

Table 9 shows the three sets of regression results classified by enterprise equity nature. Only the estimated coefficient of DIFI for private enterprises is positive and passes the significance test at the 1% level. For Sino-foreign joint ventures, the estimated coefficient of DIFI in the regression results is negative. Given that the number of observations for Sino-foreign joint ventures is only 20, this result may be caused by estimation bias due to the small sample size and thus has limited reference value; therefore, no analysis of this result is conducted here. For state-owned enterprises, the estimated coefficient of DIFI in the regression results is negative but not significant, which is also presumed to be a result of distorted outcomes caused by the small number of sample observations. Based on the research conclusions of the subgroup regression, this paper argues that the possible reason is that, compared with state-owned enterprises and foreign-funded enterprises, private enterprises are more likely to face difficulties such as financing constraints and insufficient available funds due to factors like information asymmetry and policy tendencies. In contrast, state-owned enterprises, backed by national credit, are more likely to attract investors and thus obtain funds more easily. Sino-foreign joint ventures, on the other hand, have a significant advantage in attracting foreign capital, resulting in more abundant capital. Digital finance, characterized by inclusiveness and low costs, can precisely address the funding challenges of private enterprises and meet their capital needs for development, thereby exerting a significant positive promoting effect on the high-quality development of private enterprises.

Table 9. Estimation results of enterprise heterogeneity

Nature of the enterprise	Sino-foreign joint venture	state-owned enterprise	private enterprise
The explained variable	TFP	TFP	TFP
DIFI	-2.092** (-2.554)	-0.737 (-1.018)	0.614*** (5.008)
Control variable	YES	YES	YES
Year fixed effect	YES	YES	YES
Industry fixed effect	YES	YES	YES
Observed value	20	66	652
R ²	0.982	0.678	0.448

Note: The values in parentheses are t-statistics; ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

5.4.2. Regional heterogeneity.

This paper further considers the impact of regional fixed effects. The aforementioned conclusions were derived based on controlling for industry and time effects, but they lack consideration of regional fixed effects. Therefore, to rule out the possibility that regional factors undermine the robustness of the empirical conclusions, the influence of regional fixed effects should also be taken into account. In this paper, the provinces and cities where the research samples are located are divided into three major regions: Eastern, Central, and Western China. The regional division refers to the classification standards of the National Bureau of Statistics. Subsequently, regression analyses were conducted on the above enterprise samples by region, and the estimation results are presented in Table 10.

As shown in the estimation results of Table 10, in the Eastern region, the estimated coefficient of the Digital Finance Development Index (DIFI) is positive and passes the significance test at the 10% level. Similarly, the estimated coefficient in the Central region is positive and significant at the 5%

level. However, in the Western region, although the estimated coefficient of DIFI is positive, its significance level is lower than 10% (i.e., statistically insignificant). To summarize, the development of digital finance exerts a significant promoting effect on the high-quality development of SMEs in the Eastern and Central regions, while its impact on SMEs in the Western region is relatively limited. Furthermore, the estimated coefficient of the explanatory variable (DIFI) in the Central region is larger than that in the Eastern region, indicating that the promoting effect of digital finance on SMEs in the Central region is stronger than in the Eastern region. An analysis of this phenomenon suggests the following reasons: The traditional financial market in the Eastern region is relatively mature, and the economic environment is more favorable for SME financing. The development of SMEs in this region mainly focuses on innovation, and R&D innovation requires a large amount of capital investment to achieve tangible results (thus diluting the marginal contribution of digital finance to a certain extent). In contrast, the development of traditional finance in the Central region started relatively late, making it more difficult for SMEs to obtain external financing. The inclusiveness of digital finance can precisely address this problem, thereby better promoting the high-quality development of SMEs in the Central region.

Table 10. Estimation results of regional heterogeneity

Region	Eastern region	Western region	central region
The explained variable	TFP	TFP	TFP
DIFI	0.402* (2.254)	0.247 (1.493)	1.442** (3.203)
Control variable	YES	YES	YES
Year fixed effect	YES	YES	YES
Industry fixed effect	YES	YES	YES
Observed value	469	85	138
R ²	0.382	0.907	0.648

Note: The values in parentheses are t-statistics; ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

6. Conclusions and Recommendations

This paper empirically examines the impact of digital finance on the high-quality development of small and medium-sized enterprises (SMEs) using data from SMEs listed on the Beijing Stock Exchange (BSE). The study finds that digital finance can significantly promote the high-quality development of SMEs, and this conclusion is supported by robustness tests using alternative measurement methods for high-quality development indicators. Mechanism analysis reveals that digital finance facilitates the high-quality development of SMEs through two channels: alleviating the "high cost of financing" and "difficulty in financing" faced by enterprises. Additionally, heterogeneity analysis shows that the promoting effect of digital finance on private enterprises is significantly stronger than that on state-owned enterprises, and its effect on SMEs in the Central region is more prominent—these findings well confirm the inclusive and low-cost characteristics of digital finance.

In response to the above conclusions, this paper puts forward the following policy recommendations:

First, the government should further promote the development of digital finance. According to the findings of this study, digital finance can significantly boost the high-quality development of SMEs. Therefore, the government needs to appropriately relax the policy environment, promote the integration of digital technology and financial services, and further advance digital finance to provide inclusive and targeted services for economic development.

Second, the government should emphasize the inclusive nature of digital finance development. The heterogeneity analysis results of this paper indicate that the promoting effect of digital finance on the high-quality development of SMEs is particularly significant for private enterprises. Thus, the

government should focus on leveraging digital finance to support private enterprises, break the constraints of traditional finance, and better exert its role in driving the high-quality development of SMEs. In the next step, the government can increase investment in the construction of digital finance infrastructure, including establishing secure and stable network communication systems and improving digital payment platforms. This will provide private enterprises with convenient access to financial services, reduce transaction costs, and enhance efficiency.

Third, the government should further improve the inclusive mechanism of digital finance for SMEs. Since the development of digital finance has a significant positive promoting effect on the high-quality development of SMEs, it is necessary to further optimize the exclusive transmission mechanism of digital finance for SME investment and financing, thereby giving full play to digital finance's role in promoting SME development. Furthermore, based on the finding that digital finance has a more prominent promoting effect on enterprises in the Central region, the government can be inspired to develop digital finance in regions where traditional financial markets are relatively underdeveloped. It should focus on improving digital finance infrastructure and platforms to maximize the role of digital finance in promoting SMEs.

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