Digital Finance Development and the Digital Transformation of Enterprises: Based on the Perspective of Financing Constraint and Innovation Drive

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In the context of the digital economy, the digital transformation of enterprises, as an important accelerator of new economic and social development, cannot be separated from the support of financial resources. Based on the data of China’s A-share listed companies from 2011 to 2020, this paper studies the influence of digital finance development on the digital transformation of enterprises and its mechanism of action. The empirical results demonstrate that digital finance development plays a significant role in promoting the digital transformation of enterprises, and the promotion effect is stronger for nonstate-owned enterprises, but the promotion effect of digital finance development on the digital transformation of enterprises is weaker in western regions and peripheral cities than that in eastern and central regions and central cities. Digital finance development can alleviate the financing constraint of enterprises, thus facilitating the digital transformation of enterprises. Digital finance development can drive enterprise innovation, thus promoting the digital transformation of enterprises. Therefore, this paper suggests that the government should steadily advance digital finance development. Meanwhile, financial institutions should speed up the construction of digital platforms and strengthen their support for innovative projects. In addition, enterprises should actively seize the opportunities brought by digital finance development and accelerate the construction of digital transformation.

1. Introduction

With the rapid development of information technology, especially cutting-edge digital technologies such as artificial intelligence and big data, the global economy has stepped into the era of the digital economy. At the National Conference on the Work of Cybersecurity and Informatization in 2018, Xi Jinping stated that “it is necessary to develop the digital economy, accelerate digital industrialization, rely on the innovation drive of information technology, constantly stimulate new industries, new industries and new models, and use new driving force to promote new development.” According to relevant data, the scale of China’s digital economy was nearly 39.2 trillion yuan in 2020, accounting for 38.2% of GDP. The digital economy has become a significant booster for the high-quality development of China’s economy. In 2021, the Outline of the 14th Five-Year Plan (2021-2025) for National Economic and Social Development and Vision 2035 of the People’s Republic of China pointed out “accelerating digital development and building digital China.” Against such historical background and policy guidance, enterprises and other microentities gradually consolidate their digital construction and promote digital transformation. The enterprise is the core element of the market economy. Accelerating the digitization of enterprises is conducive to promoting the development of the digital economy [1].

However, the digital transformation process of enterprises is not smooth. It encounters various difficulties, which can be classified into three categories. First, enterprises fail to carry out effective digital transformation due to their weak foundation of digital technology and lack of relevant knowledge and supporting facilities. Second, the early stage of digital transformation requires a lot of fundamental
investment, and enterprises may lack sufficient funds to support their digital transformation. Third, the digital transformation cycle is long, and enterprises frequently face the risk of declining revenue and increasing cost, thus making them unable to bear the loss caused by the cost-benefit imbalance in the process of digital transformation. From this point of view, the biggest obstacle faced by enterprises in the process of digital transformation is resource constraint. Enterprises lack sufficient resources such as capital and technology. As a result, they “do not know how to carry it out,” “cannot carry it out,” and “darn not carry it out.” Therefore, how to provide enterprises with sufficient financial resources has become a vital method to address the current problems of digital transformation [2]. In this context, digital finance is the product of the digital economy era, and it has become the general direction of financial development. Digital finance can effectively alleviate information asymmetry, improve the efficiency of financial services, and contribute to the rational allocation of financial resources [3, 4]. Meanwhile, digital finance affects the allocation of financial resources and becomes the key to solving the difficulties in the digital transformation of enterprises.

The existing research on the digital transformation of enterprises mainly focuses on four dimensions: concept definition, driving factors, realization path, and performance effect [5–12]. Some scholars have linked the financial market with the digital transformation of enterprises [13–15]. In addition, a few scholars have studied the present situation and countermeasures of digital transformation of Chinese enterprises [16].

Digital finance is an essential branch of the digital economy, and scholars have studied it extensively. The existing literature primarily carries out the research from the perspectives of digital finance development measurement, economic benefit, income gap, poverty reduction effect, environmental effect, residents’ happiness, and enterprise innovation [17–21].

The existing researches on digital finance and the digital transformation of enterprises have achieved fruitful results, affirming the significance of digital finance and the digital transformation of enterprises to economic and social development. However, no scholars have yet directly explored the relationship between digital finance and the digital transformation of enterprises. Hence, this paper theoretically expounds on the influence of digital finance on the digital transformation of enterprises and its mechanism of action. Furthermore, it empirically tests the role of digital finance in the digital transformation of enterprises and its path.

The potential marginal contributions of this paper are as follows: firstly, it is the first time to link digital finance with the digital transformation of enterprises, thus enriching the literature of digital finance. Secondly, it elaborates on the influence of digital finance on the digital transformation of enterprises and its mechanism. Meanwhile, it uses the data of China’s A-share listed companies for the empirical test. Thirdly, the conclusions of this paper can provide some policy enlightenment for the digital transformation of Chinese enterprises and help speed up the digitization process in China.

2. Theoretical Analysis and Research Hypotheses

The digital transformation of enterprises essentially means that enterprises use digital technology to transform their business activities, investment and financing activities, etc., and employ the diversity and mobility of big data to alleviate the uncertain risks faced by enterprises, thus enhancing the enterprise value and strengthening the market competitiveness. Digital transformation is not a simple technological upgrade. It is also associated with business models, production processes, production methods, and other issues. Thus, the transformation process is long-term, tortuous and uncertain [22–24]. The long period of digital transformation and the higher requirements for supporting facilities lead to higher costs and risks, which makes enterprises liable to strong financing constraint in digital transformation. When enterprises’ funds are insufficient to support the digital transformation, they will seek funds from outside to promote the digital transformation process. Moreover, the digital transformation of enterprises objectively requires a solid foundation of digital technology, largely depending on the R&D ability of enterprises. R&D innovation needs a large amount of financial support, requiring the financial market to provide sufficient financial resources. In addition, innovative projects are crucial business secrets, so enterprises often reduce the publication of related project information, which exacerbates the information asymmetry between enterprises and financial institutions, and causes financial institutions to reduce their investment in innovative projects. This is not conducive to the R&D and innovation of enterprises. It leads to the slow technical foundation improvement in the digital transformation of enterprises and decelerates the process of digital transformation [25, 26].

In a broad sense, digital finance refers to a new business model changing the trading mode and financing form of traditional financial markets based on digital technology. Affected by technology, cost, and other factors, the traditional financial market cannot effectively absorb the long-tail groups in the market, resulting in the low efficiency of financial resource allocation. On the one hand, digital finance can lower the cost of financial services, expand the audience and improve the allocation efficiency of financial resources through digital technologies such as big data and artificial intelligence, thus contributing to the flow of financial resources to enterprises with digital transformation demands and promoting their digitization process. On the other hand, the development of digital finance creates more financing ways and channels, which helps us to improve the financing flexibility of enterprises in the financial market, relieve their financing constraint, and thus increase their willingness to carry out digital transformation. Furthermore, digital finance can break geographical restrictions, enhance the communication between financial institutions, facilitate the development of small and medium-sized banks, and
intensify the competition in the banking industry, thus reducing the financing cost of enterprises and enabling enterprises to have sufficient resources for digital transformation.

Digital finance can expand the sources of funds, strengthen the information collection ability of financial institutions and reduce the information asymmetry in financial markets. Information asymmetry can lead to the rise of enterprises’ information cost and transaction cost, and weaken their investment in innovation activities, which is detrimental to their digital transformation. The development of digital finance can facilitate enterprise innovation activities, thus promoting the digital transformation of enterprises. In addition, with the help of big data and other means, digital finance helps financial institutions screen out potential innovative projects of enterprises and then directly inject funds into innovative projects. It helps to reduce R&D risks of enterprises and improve their willingness to innovate, thus driving them to increase R&D investment and promote technological development. Furthermore, the increase in innovation activities of enterprises will help them enhance their technological capabilities and reinforce their sensitivity to cutting-edge technologies, which in turn facilitate the exploration of internal and external available information, boost their information collection, integration, processing and other capabilities, and better seize the opportunities in the digital economy era. More importantly, the enhancement of enterprises’ R&D capability will boost their technological strength, and improve the hardware facilities and other basic conditions required for digital transformation, thereby promoting the digital transformation of enterprises. In light of this, this paper puts forward the following hypotheses:

H1: The development of digital finance helps the digital transformation of enterprises
H2: Digital finance promotes the digital transformation of enterprises by reducing their financing constraint
H3: Digital finance drives the digital transformation of enterprises by driving enterprise innovation

3. Research Design

3.1. Data Sources. This paper takes China’s A-share listed companies from 2011 to 2020 as research samples to explore the influence of digital finance development on the digital transformation of enterprises and its mechanism of action. The data of listed companies comes from the CSMAR database and annual reports of listed companies. The data of digital finance comes from the "Inclusive Finance Index" published by Peking University. In terms of data processing, (1) ST enterprises and listed companies in the financial industry are excluded. The main reason is that ST enterprises have a poor business operation and can easily generate extreme values, which may lead to some deviations in the results. However, the digital transformation of listed companies in the financial industry is closely associated with digital finance and may face serious colinearity, resulting in inaccurate regression results. (2) In this study, the registered places of listed companies are matched with the inclusive finance index at prefecture-level cities, and then listed companies with serious data missing are excluded. (3) Some missing data are supplemented by interpolation method, 0-value substitution, etc. Moreover, this paper carries out the two-sided 1% winsorization of the continuous variables of enterprises to prevent the extreme values from influencing the empirical results, and finally obtains 14,926 samples. The digital transformation of an enterprise means a deep transformation of the existing systems and mechanisms.

3.2. Description of Variables

3.2.1. Explained Variable: Digital Transformation (DT). The existing literature does not have a uniform standard for quantifying digital transformation. He F and Liu H have measured the digital transformation by constructing the dummy variable of “0–1.” This paper holds that this method is too vague, which may easily lead to the deviation of the results [27]. Therefore, this paper mainly refers to the practice of Wu F et al., and adopts the method of text analysis to quantify it [13]. The specific measures are as follows. Firstly, the digital transformation is divided into two categories: the application of underlying technology (AOUT) and the application of technology practice (PAOT). Secondly, the application of underlying technology is divided into four categories: cloud computing technology (CLT), artificial intelligence technology (AIT), big data technology (BDT), and blockchain technology (BT). Finally, this paper refers to the database constructed by Yi L et al., uses the crawling function of Python to make the word frequency statistics of annual reports of listed companies, sums up the number of word frequencies, and conduct logarithmic processing. The larger the index, the higher the degree of digital transformation.

3.2.2. Core Explanatory Variable: Digital Finance Development (DF). Referring to the practice of traditional literature, this paper selects the Inclusive Finance Index (prefecture-level cities) as the proxy indicator of digital finance development. The larger the value, the higher the degree of digital finance development. Otherwise, it is lower.

3.2.3. Mediating Variable. Based on the above theoretical analysis, this paper mainly selects two mediating variables, namely, financing constraint (FW) and enterprise innovation (RD). The quantitative index of financing constraint is measured by FW index. The larger the index, the higher the degree of enterprise financing constraint. Enterprise innovation is quantified by R&D investment, which is processed logarithmically.

3.2.4. Control Variables. With reference to the existing literature, the control variables in this paper are selected mainly from microenterprise characteristics and macro-economic characteristics. The microenterprise
characteristics are primarily selected from the financial perspective, value perspective, and management perspective, using debt paying ability (DPA), profitability (PA), growth ability (GA), operation capacity (OC), enterprise value (EV), and board structure (BS). The macroeconomic characteristics are mainly selected from industrial structure and economic development, using the ratio of the added value of the secondary industry in GDP (IS) and per capita gross regional product (ED), respectively, as shown in Table 1.

3.3. Model Setting. This paper focuses on the influence of digital finance development on the digital transformation of enterprises, so the following baseline model is set up for testing:

\[ DT_{i,t} = \alpha_0 + \alpha_1 DF_{j,t} + \alpha_2 Control_{i,t} + u_i + \gamma_j + \epsilon_{i,t}, \]  

(1)

where \( i \) represents the enterprise \( i \); \( t \) represents the year \( t \); \( j \) represents the prefecture-level city where the enterprise \( i \) is located; \( r \) represents the industry where the enterprise \( i \) belongs; \( DT \) represents digital transformation; \( DF \) represents digital finance development; \( Control \) represents a series of control variables; \( u_i \) represents the fixed effect of industry; \( \gamma_j \) represents the fixed effect of region; and \( \epsilon_{i,t} \) represents the random error term. It is worth noting that this whole paper adopts robust standard error for regression, and focuses on \( \alpha_1 \) in model (1). If \( \alpha_1 \) is significantly greater than 0, it indicates that digital finance development is beneficial to the digital transformation of enterprises.

To further test the influence mechanism of digital finance development on the digital transformation of enterprises, this paper mainly refers to the mediating effect model of Wen Zhonglin (2004) for testing, and the specific model is as follows:

\[
\begin{align*}
DT_{i,t} &= \beta_0 + \beta_1 DF_{j,t} + \beta_2 Control_{i,t} + u_i + \gamma_j + \epsilon_{i,t}, \\
Mediator_{i,t} &= \theta_0 + \theta_1 DF_{j,t} + \theta_2 Control_{i,t} + u_i + \gamma_j + \epsilon_{i,t}, \\
DT_{i,t} &= \alpha_0 + \alpha_1 DF_{j,t} + \alpha_2 Control_{i,t} + u_i + \gamma_j + \epsilon_{i,t}, \\
\end{align*}
\]

(2)

where \( i \) represents the enterprise \( i \); \( t \) represents the year \( t \); \( j \) represents the prefecture-level city where the enterprise \( i \) is located; \( r \) represents the industry where the enterprise \( i \) belongs; \( DT \) represents digital transformation; \( DF \) represents digital finance development; and \( Mediator \) represents mediating variables, which include financing constraint and enterprise innovation. Control, \( u_i \), \( \gamma_j \), and \( \epsilon_{i,t} \) are the same as before. This paper mainly focuses on \( \alpha_1 \), \( \beta_1 \), \( \theta_1 \), and \( \theta_2 \). If \( \alpha_1 \), \( \beta_1 \), and \( \theta_2 \) are all significant, it means that \( Mediator \) plays the mediating role in the influence of digital finance development on the digital transformation of enterprises. On this basis, if \( \theta_1 \) is also significant, it is the partial mediator. If \( \theta_1 \) is not significant, it is the complete mediator.

3.4. Descriptive Statistical Analysis. Table 2 presents the descriptive statistical results of variables. It shows that the maximum value of InDT is 5.024, which means the frequency of digital transformation-related words in annual reports of the enterprises with the highest degree of digital transformation among the samples is 152. The minimum value of InDT is 0, which means that the frequency of digital transformation-related words in annual reports of the enterprises with the highest degree of digital transformation among the samples is only 1. It indicates that there are huge differences among different enterprises.

4. Empirical Results and Analysis

4.1. Results of the Baseline Regression. The baseline model of this paper is a panel model of double fixed effect, with the fixed effect of industry and the fixed effect of region. This paper employs progressive regression. Table 3 reports the results of the baseline regression. Column (1) shows the mixed regression results without adding control variables and fixed industry or region. Column (2) shows the regression results of adding control variables based on the previous one. Column (3) and Column (4) show the results of fixed industry and fixed region, respectively. Column (5) shows the results of fixed both industry and region. The DF regression coefficients in Columns (1), (2), (3), (4), and (5) are all significantly positive at the level of 1%. It indicates that digital finance development can promote the digital transformation of enterprises, thereby verifying hypothesis 1. This paper holds that digital finance development can increase the supply of financial resources for enterprises in need of digital transformation, thus providing enterprises with sufficient funds to support their digital transformation and improving their willingness to carry out digital transformation. In addition, the development of digital finance is conducive to the flow of information within the market, which helps enterprises better grasp the market trends, and facilitates them to obtain information related to digital transformation, thus enabling them to carry out digital transformation better.

4.2. Robustness Test

4.2.1. Endogenous Treatment. Even if the double fixed effect model is adopted, the empirical results of this paper may still have endogenous problems, such as reverse causality, missing variables, and measurement errors. To address this concern, this paper employs the instrumental variable method for regression. The source of the digital finance index is Ant Group, and there are many digital finance platforms in Hangzhou. The closer an enterprise is to Hangzhou, the greater the influence of digital finance. Therefore, the distance between the enterprise’s location and Hangzhou has a correlation with the development level of digital finance. However, the variable of distance is not directly related to the development of the enterprise itself, but it meets the exogenous conditions. However, this distance is cross section data and does not change with time. Hence, this paper interacts it with the average value of digital finance after excluding its own value in each city in the previous year to obtain the instrumental variable and match it with the model. The regression results of the instrumental variable method are shown in Table 4. Columns (1), (2), and
present the results of the instrumental variable method under the fixed effect model. It can be observed that the estimation coefficient of digital finance (DF) is still significantly positive, which indicates that the previous estimation results are robust. In addition, both the Kleibergen-Paap rk LM value and Kleibergen-Paap rk Wald F value pass the significance test, suggesting that the selection of the instrumental variable in this paper is reasonable.

Table 1: Variable descriptions.

<table>
<thead>
<tr>
<th>Variable type</th>
<th>Variable name</th>
<th>Variable definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Explained variable</td>
<td>Digital transformation</td>
<td>Count the number of words related to digital transformation appearing in the annual reports of listed companies, sum them up to indicate the degree of digital transformation, and then represent it by DT.</td>
</tr>
<tr>
<td>Exploratory variable</td>
<td>Digital finance development</td>
<td>With reference to the practice of traditional literature, the digital inclusive finance index serves as its proxy indicator, represented by DF.</td>
</tr>
<tr>
<td>Mediating variable</td>
<td>Financing constraint</td>
<td>The FW index serves as its proxy variable, represented by FW.</td>
</tr>
<tr>
<td></td>
<td>Enterprise innovation</td>
<td>R&amp;D investment serves as its proxy variable and is logarithmically processed, represented by RD.</td>
</tr>
<tr>
<td>Enterprise control</td>
<td>Debt paying ability</td>
<td>Asset-liability ratio serves as its proxy indicator, represented by DPA.</td>
</tr>
<tr>
<td></td>
<td>Profitability</td>
<td>The growth rate of operating income serves as its proxy indicator, represented by GA.</td>
</tr>
<tr>
<td></td>
<td>Growth ability</td>
<td>Total asset turnover serves as its proxy indicator, represented by OC.</td>
</tr>
<tr>
<td></td>
<td>Operation capacity</td>
<td>Tobin Q value serves as its proxy index, represented by EV.</td>
</tr>
<tr>
<td></td>
<td>Enterprise value</td>
<td>The ratio of the number of independent directors to the number of the board of directors serves as its quantitative index, represented by BS.</td>
</tr>
<tr>
<td>Macrocontrol variable</td>
<td>Industrial structure</td>
<td>The ratio of the added value of the secondary industry in GDP serves as the proxy index, represented by IS.</td>
</tr>
<tr>
<td></td>
<td>Economic development</td>
<td>The per capita gross regional product serves as its proxy indicator and is logarithmically processed, represented by ED.</td>
</tr>
</tbody>
</table>

Table 2: Descriptive statistical analysis.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Obs</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>DT</td>
<td>14940</td>
<td>15.778</td>
<td>25.828</td>
<td>1</td>
<td>152</td>
</tr>
<tr>
<td>lnDT</td>
<td>14940</td>
<td>1.837</td>
<td>1.347</td>
<td>0</td>
<td>5.024</td>
</tr>
<tr>
<td>POAT</td>
<td>14940</td>
<td>8.886</td>
<td>13.282</td>
<td>1</td>
<td>81</td>
</tr>
<tr>
<td>AOUT</td>
<td>14940</td>
<td>8.464</td>
<td>16.385</td>
<td>1</td>
<td>104</td>
</tr>
<tr>
<td>LnPOAT</td>
<td>14940</td>
<td>1.516</td>
<td>1.093</td>
<td>0</td>
<td>4.394</td>
</tr>
<tr>
<td>LnAOUT</td>
<td>14940</td>
<td>1.198</td>
<td>1.23</td>
<td>0</td>
<td>4.644</td>
</tr>
<tr>
<td>DF</td>
<td>14940</td>
<td>238.763</td>
<td>61.145</td>
<td>30.7</td>
<td>334.48</td>
</tr>
<tr>
<td>FC</td>
<td>14940</td>
<td>0.485</td>
<td>0.294</td>
<td>0</td>
<td>1.001</td>
</tr>
<tr>
<td>RD</td>
<td>14940</td>
<td>1.659e+08</td>
<td>4.079e+08</td>
<td>0</td>
<td>3.035e+09</td>
</tr>
<tr>
<td>lnRD</td>
<td>14940</td>
<td>16.045</td>
<td>5.62</td>
<td>0</td>
<td>21.833</td>
</tr>
<tr>
<td>DPA</td>
<td>14940</td>
<td>0.414</td>
<td>0.207</td>
<td>0.053</td>
<td>0.943</td>
</tr>
<tr>
<td>PA</td>
<td>14940</td>
<td>0.037</td>
<td>0.077</td>
<td>-0.343</td>
<td>0.227</td>
</tr>
<tr>
<td>GA</td>
<td>14940</td>
<td>0.17</td>
<td>0.452</td>
<td>-0.656</td>
<td>2.896</td>
</tr>
<tr>
<td>OC</td>
<td>14940</td>
<td>0.637</td>
<td>0.452</td>
<td>0</td>
<td>2.613</td>
</tr>
<tr>
<td>EV</td>
<td>14940</td>
<td>2.661</td>
<td>2.089</td>
<td>0</td>
<td>12.058</td>
</tr>
<tr>
<td>BS</td>
<td>14940</td>
<td>0.378</td>
<td>0.054</td>
<td>0.333</td>
<td>0.571</td>
</tr>
<tr>
<td>IS</td>
<td>14940</td>
<td>39.559</td>
<td>9.429</td>
<td>15.8</td>
<td>59</td>
</tr>
<tr>
<td>ED</td>
<td>14940</td>
<td>83678.775</td>
<td>33448.885</td>
<td>16411.994</td>
<td>164888.53</td>
</tr>
<tr>
<td>lnED</td>
<td>14940</td>
<td>11.252</td>
<td>0.415</td>
<td>9.706</td>
<td>12.013</td>
</tr>
</tbody>
</table>

Table 3: Baseline regression.

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DF</td>
<td>0.0043***</td>
<td>0.0035***</td>
<td>0.0048***</td>
<td>0.0034***</td>
<td>0.0046***</td>
</tr>
<tr>
<td></td>
<td>(24.56)</td>
<td>(16.01)</td>
<td>(25.37)</td>
<td>(4.99)</td>
<td>(7.94)</td>
</tr>
<tr>
<td>Control</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Fixed effect of industry</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>Fixed effect of region</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>N</td>
<td>14926</td>
<td>14926</td>
<td>14926</td>
<td>14926</td>
<td>14926</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.0388</td>
<td>0.0645</td>
<td>0.3405</td>
<td>0.1382</td>
<td>0.3724</td>
</tr>
</tbody>
</table>

Note: *, **, and *** are significant at the levels of 10%, 5%, and 1%, respectively. The t value under the robust standard error is in brackets.
4.2.2. Change the Calculation Caliber. Firstly, this paper decomposes the caliber of the digital transformation of enterprises, reduces its dimension according to the proxy indicator composition of digital transformation, decomposes it into two sub-indexes of “the application of underlying technology” and “the application of technology practice,” carries out logarithmic processing, and then makes regression, respectively. The regression coefficients of digital finance development are both positive and highly significant in the regressions of the application of underlying technology and the application of technology practice in Column (1) and Column (2) of Table 5, which indicates that digital finance development has a significant role in promoting the application of underlying technology and the application of technology practice. Secondly, this paper decomposes the caliber of digital finance, reduces it to three levels: coverage breadth (DFA), coverage depth (DFD), and digitization degree (DFE) according to the decomposition method of the Digital Inclusive Finance Index published by Peking University, and then makes regression, respectively. The results are shown in Columns (3) to (5) of Table 5. The results demonstrate that the regression coefficients of DFA, DFD, and DFE are all significantly positive, indicating that the coverage depth, coverage breadth, and digitization degree of digital finance all positively affect the digital transformation of enterprises. The above empirical results can verify that the promotion of digital finance development to the digital transformation of enterprises is robust.

4.2.3. Extend the Observation Period of Variables. As shown in Table 6, to explore whether digital finance development can promote the digital transformation of enterprises for a long time and investigate the dynamic influence of digital finance development on the digital transformation of enterprises, this paper regresses the digital finance and the digital transformation of enterprises by three lag periods and three advanced periods, respectively. The regression results show that the three lag term coefficients of digital finance development are significantly positive in the lag period of digital finance development (DT) in Column (1) to Column (3). In the advanced period of digital transformation (DT) in Column (4) to Column (6), the driving effect of digital finance development on digital transformation is still significantly positive, suggesting that the promotion effect of digital finance development on the digital transformation of enterprises has some superposition effect for a long time. This further demonstrates the robustness of the baseline regression model and verifies the regression conclusions of this paper.

4.3. Heterogeneity Analysis. First of all, based on the differences of ownership nature among different enterprises, this paper discusses the heterogeneity of ownership nature in the influence of digital finance development on the digital transformation of enterprises. Specifically, according to the ownership nature of enterprises, this paper constructs the dummy variable, Nature, with the value of 1 for state-owned enterprises and 0 for nonstate-owned enterprises. Then, the interactive term between digital finance development and the dummy variable of ownership nature is constructed and brought into the baseline model for regression. The results are shown in Table 7 (1). It indicates that the regression coefficient of digital finance development on the digital transformation of enterprises is significantly positive, while the estimation coefficient of the interactive term between digital finance development and the dummy variable of ownership nature is significantly negative. The above results indicate that digital finance development can effectively drive the digital transformation of enterprises, but the driving effect is significantly weaker in state-owned enterprises than that in nonstate-owned enterprises. This may be due to the following reasons. First, state-owned enterprises have their special political status. In other words, the invisible participation of government departments renders it evident advantages in obtaining credit funds, so they have less capital constraint. Therefore, they respond slowly to the supply of financial resources brought by the development of digital finance, and it exerts little effect on promoting their digital transformation. Secondly, due to the special political status and economic strength of state-owned enterprises, they are easier to gain market share, which leads to their reduced willingness to innovate and less endogenous demand for digital transformation. Furthermore, this reduces their willingness to invest in digital transformation and innovation, thus leading to a low degree of digital transformation of state-owned enterprises. In contrast, nonstate-owned enterprises have a much stronger demand for financial resources than state-owned enterprises. Digital finance development can optimize the allocation of financial resources, thus breaking the constraint of resource boundary of nonstate-owned enterprises. Besides, nonstate-owned enterprises confront much higher competitive pressure than state-owned enterprises, so they have a stronger willingness to carry out digital transformation. Therefore, digital finance development can better meet the capital and innovation needs of nonstate-owned enterprises, and they have more funds to support digital transformation and innovation activities. Thus, the driving effect of digital finance development on the digital transformation of enterprises is significantly different among enterprises with different natures.

Secondly, based on the location differences of cities where enterprises are located, this paper studies the location heterogeneity characteristics in the influence of digital finance development on the digital transformation of enterprises. Specifically, this paper sets the region dummy variable, West, with the value 1 for western regions and the value 0 for nonwestern regions, and introduce its product with digital finance development into the baseline model for regression. The results are shown in Column (2) of Table 7. The results demonstrate that the estimation coefficient of digital finance development on the digital transformation of enterprises is significantly positive, while the estimation coefficient of the interactive term between digital finance development and the dummy variable of region is significantly negative. The above results indicate that digital finance development can effectively drive the digital transformation of enterprises, but the driving effect is
significantly weaker in western regions than in the eastern and central regions. The reason may be that western regions have a weaker level of digital finance development due to relatively weak levels of technological development, economic strength, infrastructure, and other aspects, thus the driving effect of digital finance on the digital transformation of enterprises is small. However, nonwestern regions have some advantages in education, economy, society, and technological level. As a result, digital finance plays a stronger marginal role in promoting the digital transformation of enterprises there.

Finally, according to the economic function of the cities where enterprises are located, this paper divides the samples into two groups, central cities and peripheral cities, to explore the heterogeneity of city functions in the influence of digital finance development on the digital transformation of enterprises. Specifically, provincial capital cities and municipalities directly under the Central Government are

\[
\begin{array}{lcccc}
\text{Table 4: Regression results of the instrumental variable method.} \\
(1) & (2) & (3) & (4) & (5) \\
\hline
\text{DF} & 0.0055^{***} & 0.0095^{**} & 0.0090^{**} & \\
& (11.61) & (2.25) & (2.51) & \\
\text{Control} & Y & Y & Y & Y \\
\text{Fixed effect of industry} & Y & Y & Y & Y \\
\text{Fixed effect of region} & Y & Y & Y & Y \\
\text{Kleibergen-Paap rk LM } P \text{ value} & 0.0000 & 0.0000 & 0.0000 & \\
\text{Kleibergen-Paap rk Wald } F \text{ value} & 2690.488 & 258.704 & 295.891 & \\
N & 14429 & 14416 & 14416 & \\
R^2 & 0.0531 & 0.0354 & 0.0486 & \\
\hline
\end{array}
\]

Note. *, **, and *** are significant at the levels of 10%, 5%, and 1%, respectively. The t value under the robust standard error is in brackets.

\[
\begin{array}{lcccc}
\text{Table 5: Robustness test 1: change the calculation caliber.} \\
(1) & (2) & (3) & (4) & (5) \\
\hline
\text{DF} & 0.0036^{***} & 0.0039^{***} & 0.0016^{***} & 0.0025^{***} \\
& (7.10) & (7.40) & (3.97) & (7.48) \\
\text{DFA} & 0.0051^{***} & \\
& (8.06) & \\
\text{DFD} & \\
\text{DFE} & Y & Y & Y & Y \\
\text{Fixed effect of industry} & Y & Y & Y & Y \\
\text{Fixed effect of region} & Y & Y & Y & Y \\
N & 14926 & 14926 & 14926 & 14926 \\
R^2 & 0.4505 & 0.2457 & 0.3726 & 0.3720 & \\
\hline
\end{array}
\]

Note. *, **, and *** are significant at the levels of 10%, 5%, and 1%, respectively. The t value under the robust standard error is in brackets.

\[
\begin{array}{lcccc}
\text{Table 6: Robustness test 2: extend the observation period.} \\
(1) & (2) & (3) & (4) & (5) & (6) \\
\hline
\text{DF} & 0.0049^{***} & 0.0050^{***} & 0.0053^{***} & \\
& (6.55) & (4.63) & (4.68) & \\
\text{LDF} & 0.0032^{***} & \\
& (4.50) & \\
\text{L2.DF} & 0.0035 & \\
& (4.21) & \\
\text{L3.DF} & 0.0024 & \\
& (3.08) & \\
\text{Control} & Y & Y & Y & Y & Y \\
\text{Fixed effect of industry} & Y & Y & Y & Y & Y \\
\text{Fixed effect of region} & Y & Y & Y & Y & Y \\
N & 9971 & 7864 & 6857 & 9972 & 7862 & 6856 \\
R^2 & 0.3718 & 0.3794 & 0.3892 & 0.3609 & 0.3593 & 0.3610 \\
\hline
\end{array}
\]

Note. *, **, and *** are significant at the levels of 10%, 5%, and 1%, respectively. The t value under the robust standard error is in brackets.
To further test the mechanism of digital finance development affecting the digital transformation of enterprises, this paper selects two mediating variables, financing constraint, and enterprise innovation. Meanwhile, it uses the mediating effect model to test. The results are shown in Table 8. Columns (1), (2), and (3) examine whether digital finance development can affect the digital transformation of enterprises by influencing the financing constraint. Among them, Column (1) suggests that digital finance development significantly drives the digital transformation of enterprises, which is consistent with the result of the aforementioned baseline regression model. Column (2) shows that digital finance development significantly restrains the financing constraint of enterprises, which is consistent with the research conclusions of Liang B et al. and Yu P et al. [28, 29]. Column (3) further demonstrates the impact of digital finance development on the digital transformation of enterprises. It shows that the regression coefficient of digital finance development is significantly positive, indicating that digital finance development can drive the digital transformation of enterprises. In combination with Column (1) and Column (2), it can be observed that digital finance development can significantly restrain the financing constraint and further promote the digital transformation of enterprises. In the meantime, the financing constraint acts as the partial mediator in digital transformation driven by digital finance development. This means that digital finance development can alleviate the financing constraint faced by enterprises, make them optimize production and operation, and facilitate their digital transformation strategies, thus forming a positive path of “digital finance development → (drive) enterprise financing constraint → (relieve) digital transformation.” In Column (3), the regression coefficient of financing constraint is significantly negative, which provides strong evidence support for the above logic.

Columns (1), (4), and (5) examine whether digital finance development can influence the digital transformation of enterprises by influencing enterprise innovation. Among them, Column (4) shows that digital finance development significantly drives enterprise innovation, which is consistent with the research results of Liang B and Tang S. Column (5) further demonstrates the influence of digital finance development on the digital transformation of enterprises. It is found that the regression coefficient of digital finance development is significantly positive, indicating that digital finance development can drive the digital transformation of enterprises. In combination with Column (1) and Column (2), it can be observed that digital finance development can significantly promote enterprise innovation and further drive the digital transformation of enterprises. Meanwhile, enterprise innovation acts as a partial mediator in the process of digital finance development driving the digital transformation of enterprises. It means that digital finance development can optimize the allocation of financial resources and lead to the flow of funds to enterprises with high marginal output, thus increasing of enterprises’ investment in innovation activities, and facilitating digital transformation. Based on this, a positive path of “digital finance development → (drive) enterprise innovation → (drive) digital transformation” is formed. In Column (5), the regression coefficient of enterprise innovation is significantly positive, which provides evidence for the above analysis.

<table>
<thead>
<tr>
<th>Table 7: Heterogeneity test.</th>
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<tr>
<td>Ownership nature</td>
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<tr>
<td>DF</td>
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<tr>
<td>Nature*DF</td>
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<td>West*DF</td>
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<tr>
<td>N</td>
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<td>$R^2$</td>
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Note. *, **, and *** are significant at the levels of 10%, 5%, and 1%, respectively. The t value under the robust standard error is in brackets.
5. Conclusions and Suggestions

Based on the data of China’s A-share listed companies from 2011 to 2020 and the Digital Inclusive Finance Index data published by Peking University, this paper explores the influence of digital finance development on the digital transformation of enterprises and its mechanism of action, empirically tests the driving force and mechanism of digital finance development on the digital transformation of enterprises, and draws the following conclusions.

First, digital finance development can significantly affect the digital transformation of enterprises. The higher the level of digital finance development, the higher the degree of the digital transformation of enterprises. Second, the driving effect of digital finance development on the digital transformation of enterprises can be largely different due to the nature of enterprises, geographical location, and urban economic functions. Specifically, compared with state-owned enterprises, digital finance development has a greater driving effect on nonstate-owned enterprises. Compared with western regions, digital finance development in the eastern and central regions plays a greater role in driving the digital transformation of enterprises. Compared with peripheral cities, digital finance development in central cities plays a greater role in driving the digital transformation of enterprises. Third, from the perspective of mechanism, digital finance development can significantly relieve the financing constraint of enterprises, and help enterprises to innovate, thus driving the digital transformation of enterprises.

This paper puts forward the following policy suggestions according to the above conclusions.

First, the government should steadily promote digital finance development, give full play to the role of finance in promoting the real economy, effectively optimize the allocation of financial resources, and inject impetus into the digital transformation of enterprises. In particular, banks and other financial institutions should strengthen supervision over digital transformation projects of state-owned enterprises to better promote the influence of digital finance development on the digital transformation and provide assistance for digital transformation of the whole society. Third, enterprises should proactively adapt to the opportunities brought by digital finance development, concentrate resources on building digital infrastructure, and accelerate the process of digital transformation. State-owned enterprises should make use of their own advantages to increase investment in digital transformation and better accelerate the digital transformation of the whole society.

### Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

### Conflicts of Interest

The author declares no conflicts of interest.

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### References


