Research Article

Research on the Impact of Digital Finance on the Green Development of Chinese Cities

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This paper takes 286 prefecture-level Chinese cities from 2011 to 2019 as research objects. It empirically examines the influence of digital finance on green development by using the EBM model, two-way fixed effect model, and instrumental variable method. It is found that digital finance can significantly promote the green development of Chinese cities, and this conclusion is still valid after the robustness tests, such as the instrumental variable method dealing with endogeneity and two-sided winsorization. The mechanism analysis results suggest that only the breadth of digital finance can significantly promote green development in the internal mechanism of digital finance, but the effect of coverage depth and digitization degree is not significant. The external mechanism of industrial structure upgrading assumes the mediating role of digital finance in improving the level of green development. The heterogeneity analysis results show that digital finance has a stronger impact on green development in the central and western cities and small-scale cities. This paper contributes to the study of the relationship between digital finance and green development and puts forward relevant suggestions.

1. Introduction

China’s current economic development has moved towards the path of high-quality development. It has become a critical issue to realize the transformation of the speed-oriented economy to the quality-oriented economy. China’s rapid economic growth since the reform and opening-up has been realized in an extensive development mode with high pollution and high energy consumption, which has brought serious impacts on China’s energy resources and ecological environment. Economic transformation has now become a critical path. The 2021 Sustainable Development Report released by the Institute for Sustainable Development Goals, Tsinghua University, points out that China’s sustainable development index is 72.1, ranking 57th among 165 countries in the world. In September 2020, President Xi Jinping attended the United Nations General Assembly and proposed that China need to reach peak carbon dioxide emissions by 2030 and strive to achieve carbon neutrality by 2060. This implies that the economic and social development mode emphasizing reducing carbon emissions and promoting green development has become the focus.

Finance is the bloodline of the modern economy, and digital finance is a financial innovation that combines traditional finance with technologies such as big data and artificial intelligence. The development of digital finance has addressed the problems such as information asymmetry, provided crucial financial support, supported the development of real economy such as small- and medium-sized enterprises, reduced costs for the development of high-tech and low-carbon clean enterprises, and made the information of enterprises more transparent, thus making the utilization of funds easy to be monitored and helping prevent and eliminate risks. There have been many studies on the role of digital finance and the influencing factors of green development, but there are few studies on the relationship between digital finance and green development. Some scholars find that digital finance can improve the green total factor productivity [1–3]. However, they mainly proceed from the perspectives of factor distortion, resource mismatch,
Innovation, and entrepreneurship. Their measurement models all adopt the SBM model, only considering the nonradial relationship between the input and output. However, both radial and nonradial relationships exist in actual production. The omission of this factor may lead to deviation in the measurement [4]. Therefore, this paper uses the panel data of 286 Chinese cities from 2011 to 2019, employs the mixed distance function, EBM model, to measure the green total factor productivity, and matches it with the digital inclusive finance index. On this basis, it uses cartographic visualization, two-way fixed effect model, instrumental variable method, and mediating effect model to examine the relationship and mechanism between digital finance and green development and further explores the heterogeneity.

The possible contributions of this paper are as follows. Firstly, the existing studies seldom conduct research from the perspective of the internal and external mechanisms of digital finance. This paper studies the internal and external mechanisms and verifies their existence in different ways. Secondly, the existing studies on digital finance and the green total factor productivity mainly adopt the SBM model, only considering nonradial function. This paper adopts mixed distance function, EBM model, which can better reduce the error in measurement. Thirdly, this paper uses the number of urban telephones in 1984 as an instrumental variable to identify the causal relationship between digital finance and green development, which helps alleviate the endogenous problems related to the research of digital finance and green development.

This paper is arranged as follows. The second part presents the theoretical analysis and shows that digital finance has a positive effect on green development. The third part introduces the empirical model of this paper and measures the green total factor productivity. The fourth part verifies that digital finance can promote green development and further tests its mechanism and heterogeneity. The fifth part further discusses the empirical results of this paper and proposes policy suggestions.

2. Theoretical Basis and Research Hypotheses

Green development is a way of economic growth and social development aiming at efficiency, harmony, and sustainability. As the theme of progress and development in the new era, it not only inherits the goal of sustainable development, but also innovates the theory of sustainable development in China. Green development possesses three characteristics, namely, systematic coordination, global sharing, and social practice. Jiang Nanning and others [5] argue that the core of green development is the combination and efficient utilization of resources and environmental energy, the common development of economy and society, and the harmonious existence between man and nature. The joint research group of the World Bank and the Development Research Center of the State Council believes that economic growth should be moderate, rather than excessively relying on resources, carbon emissions, and environmental damage. Green development is creating new green products, technologies, and investment. Hu Angang and others [6] think that the main characteristics of green development are moderate consumption, low energy consumption, low emission, and the continuous expansion of ecological resources, coordinating the three systems of economy, nature, and society.

Financial development can significantly affect green development, which has been supported by many studies. Financial factor cluster has a significant spatial spillover effect on green development, and this effect embodies significant characteristics of spatial decline. Financial cluster also influences green development through capital support, resource allocation, and innovation [7]. Huang Jianhuan and others [8] think that the enterprise supervision effect plays a substantial role in the influence mechanism of financial development on green development, while the green financial effect is not strong. In terms of industry, Guo Wei and Si Menghui [9] conclude that financial cluster has an inverted "U" shape relationship with green total factor productivity in manufacturing industry, and it mainly generates the influence through improving technological capabilities. Some researchers believe that financial development can reduce the green total factor productivity. For example, Ge Pengfei and others [10] find that financial development can reduce the green total factor productivity by using the cross-border panel data of the "Belt and Road Initiative," while fundamental innovation and application innovation can mitigate the negative effect.

With the development of Alipay and other platforms, the development speed of digital finance in China is extremely rapid, which has caused tremendous impacts on people's life. In terms of the studies on the impact of digital finance, many researchers have studied the macro and micro effects of digital finance. Yi Hang and Zhou Li [11] find that digital finance can significantly improve residents' consumption and play a more prominent role in the "vulnerable" groups in rural areas and central and western cities, thus proving the inclusive characteristics of digital finance. Qian Haizhang and others [12] think that digital finance has a significant impact on China's economic growth, and its mechanism is to drive the development of innovation and entrepreneurship. Song Min and others [13] put forward that financial technology can empower enterprises, reduce information asymmetry, improve the relationship between banks and enterprises, and ease financing constraints and other issues, thus improving the total factor productivity of enterprises. Tang Wenjin and others [14] state that digital finance has a nonlinear influence on the industrial structure upgrading by using the panel data of prefecture-level Chinese cities. In terms of the literature on the relationship between digital finance and environmental governance, Fang Lin and Yang Siying [15] think that financial technology can reduce urban pollution, presenting a significant emission reduction effect. Zheng Wanteng and others [16] argue that digital finance can significantly control environmental pollution, and its primary mechanism is to promote social development, industrial upgrading, and green technology innovation. Based on the previous literature, this paper puts forward the following hypotheses:
(i) H1: Digital finance can promote green development.

(ii) H2: Digital finance can promote green development through industrial structure upgrading.

3. Research Design

3.1. Model Specification.

\[ \ln(gtfp) = \alpha_0 + \alpha_1 \ln(dfi) + \alpha_2 \text{controls}_{it} + \phi_i + \pi_t + \epsilon_{it}. \]  

In this model, subscript \( i \) indicates city identification and year identification. \( \ln(gtfp) \) represents the explained variable, the green total factor productivity. \( \ln(dfi) \) represents the core explained variable, digital finance. “controls” represents a series of control variables. \( \phi_i \) represents the city fixed effect. \( \pi_t \) represents the year fixed effect. \( \alpha_0 \) represents the intercept term of the equation. \( \epsilon_{it} \) represents the random disturbance term that varies with individuals and time. The empirical model adopted in this paper is a two-way fixed effect model, which can alleviate endogenous problems caused by factors such as missing variables.

3.2. Data Sources and Variable definitions. This paper uses the balanced panel data of 2,574 observations in 286 cities from 2011 to 2019 for empirical research. The primary data sources are the CSMAR Database, China Urban Statistical Yearbook, and Institute of Digital Finance Peking University. All the variables related to prices are deflated while taking the year 2010 as the base year.

Explained variable (\( \ln(gtfp) \)): the existing methods to measure green development are mainly divided into index system method and model efficiency method. The index system method mainly uses a variety of indexes to measure development performance. Chen et al. [17] employ 32 indexes to systematically evaluate the interprovincial industrial green development level in China from four aspects: industrial green output, innovation, efficiency, and policy. The model efficiency method mainly utilizes data envelopment analysis. Feng et al. [18] measure the development status through the green development performance index from the perspective of regions and evaluate the green development status of more than 40 regions in the world based on the expert scoring and data envelopment method. There are also studies using the methods such as stochastic frontier method and exponential method [19, 20]. In this paper, DEA software is used to measure the green total factor productivity of Chinese cities through the EBM model considering the undesirable output and Malmquist-Luenberger productivity index method. The year 2010 is defined as the base period, and then the green total factor productivity is measured. Finally, the logarithmic value is taken as the explained variable in this paper.

The indexes for calculating green total factor productivity are as follows. 1. Input indexes: in this paper, input elements include labor, capital, and energy. The number of employees in state-owned units and private units in various prefecture-level cities is taken as labor input indexes. The sum of household electricity consumption and industrial electricity consumption in the whole city is used to measure the energy input. The capital input is measured by the perpetual inventory method, in which the depreciation rate is set at 10.96%. 2. Output indexes: output indexes are divided into desired output and undesirable output. The desired output is constant-price GDP and green coverage of built-up areas, while the undesirable output is industrial smoke, industrial sulfur dioxide, and industrial wastewater. To reduce the efficiency reduction caused by too many variables, this paper uses entropy method to synthesize three indexes of undesirable output into one index.

Core explanatory variable (\( \ln(dfi) \)): referring to the research of Guo Feng et al., this paper uses the digital inclusive finance index published by the Institute of Digital Finance Peking University to measure the development of digital finance in Chinese cities. Its logarithmic value is taken as the core explanatory variable to reduce the influence of heteroscedasticity [21].

Control variables: referring to the existing literature, this paper introduces a series of economic and social control variables. Economic development level (\( \text{LNP GDP} \)) is represented by the logarithmic value of per capita GDP. Human capital level (\( \text{edu} \)) is represented by the proportion of college students to urban population. Urban scale (\( \ln(urban) \)) is represented by the logarithmic value of population density. Foreign investment level (\( \text{fdi} \)) is represented by the ratio of actual foreign direct investment to GDP adjusted by exchange rate. Financial development level (\( \text{finance} \)) is represented by the proportion of year-end loan balance in financial institutions to GDP. Descriptive statistics of related variables are shown in Table 1. The mean value of the green total factor productivity (\( \text{gtfp} \)) is 1.05, indicating that the green total factor productivity of Chinese cities is on the rise from 2011 to 2019. The standard deviation of human capital (\( \text{edu} \)) of cities is large, suggesting that the human capital level of Chinese cities is quite different. In addition, the characteristics of each variable in this paper are similar to those in previous studies.

To observe the evolution of the green total factor productivity and digital finance more intuitively, this paper visualizes it in Figure 1 with Stata15.0. In terms of the green total factor productivity, it can be seen from the comparison between 2011 and 2019 that the maximum and minimum values increase substantially, especially in the northeast, central, and western cities. The deeper color indicates that its absolute value increases, and its ranking also rises substantially. For digital finance, the minimum value increases from 17.02 to 199.54, and the maximum value increases from 86.51 to 321.65, indicating that the overall development of digital finance is also improving. In addition, the color of digital finance in the central region is obviously deepened, indicating that digital finance in the central region is developing at a fast speed.

4. Empirical Results and Economic Explanations

This part tests the previous hypotheses. Before the empirical analysis, it is necessary to conduct multicollinearity test on the model. The results show that the vif values are all less
than 2.08, far less than 10, indicating that there is no multicollinearity in the empirical model of this paper. In addition, it also passes the F test, LM test, and Hausman test, confirming that it is reliable to choose the fixed effect model, as demonstrated in Table 2.

4.1. Baseline Regression. Firstly, this paper examines the relationship between digital finance and urban green development. The corresponding results are summarized in Table 3. In this paper, the two-way fixed effect model is taken as the baseline model, and stepwise regression is carried out by adding control variables step by step to verify the robustness of the results. In Columns (1) to (6), the coefficients of digital finance (\( \text{Lndfi} \)) are all positive and significant at the level of 1%, which indicates that digital finance has the green growth effect and significantly promotes the green total factor productivity. Among them, the coefficient of digital finance in Column (6) is 0.0377, indicating that the logarithm of green total factor productivity increases by
3.77% for every 1 unit increase in the logarithm of digital financial index. Digital finance relies on big data, artificial intelligence, and other means to improve the efficiency of information matching, lower service costs, and optimize the distribution of production factors. Moreover, the transparency of its information makes it easier to distinguish between green industries and green companies, laying a solid foundation for the improvement of green development. Then, hypothesis 1 is preliminarily verified.

For control variables, the coefficient of human capital (edu) is 0.0065, which is significant at the level of 1%, indicating that the improvement of urban human capital can significantly improve the urban green total factor productivity. The coefficient of urban scale (lnurban) is 0.0488, which is significant at the level of 1%, indicating that the increase of urban population density can improve the level of green total factor productivity. Finally, the coefficient representing the level of traditional finance (finance) is 0.0061, which is significant at the level of 1%. It suggests that digital finance does not play a role of substitution, and traditional finance can still have an impact on green development.

### 4.2. Endogenous Treatment and Robustness Test

#### 4.2.1. Instrumental Variable Method

Even if the two-way fixed effect model is adopted, endogenous problems may still exist in this study. To address this concern, this paper refers to the practice of Huang Qunhui and others [22] and uses the number of telephones per 10,000 households in various regions in 1984 as an instrumental variable method. It is because the historical data can meet the exogeneity, and the development of communication technology and digital finance in history also meets the relationship. This variable is the cross-sectional data, which cannot match the panel data, so the mean value of digital finance in each region except itself in the previous year is taken as the trend item with dynamic changes. After multiplying it by the number of telephones owned by every 10,000 households in 1984, the instrumental variable of this paper is obtained.

Column (1) of Table 4 reports the regression results of the instrumental variable. The coefficient of digital finance (lnfin) is 0.2361, which shows that the impact of digital finance on green total factor productivity is still significant at the positive level of 1% after considering endogenous problems, which is basically consistent with the previous results of baseline model. They all pass the K–P rk LM test and K–P rk Wald F test, showing that the selection of the instrumental variable is reasonable and valid.

#### 4.2.2. Control Macro Factors

The fixed effect model adopted in this paper is the year-city two-way fixed effect. Because each region may have different characteristics that change at any time, the two-way fixed effect model may not be rigorous enough. Therefore, this paper takes the interaction term of year and province into the model and considers the characteristics of the region changing with time to further test the conclusions. The corresponding results are presented in Column (2) of Table 4. The coefficient of digital finance is 0.0358, which is significant at the level of 1%, indicating that the previous conclusion is robust.

#### 4.2.3. Eliminate Interference Factors

Winsorization treatment: considering that the development levels of cities are quite different, there may be abnormal values in each variable. To eliminate the influence of abnormal values on the results of this paper, the variables undergo the winsorization treatment of 1% on both sides, and the corresponding results are reported in Column (3) of Table 4. The coefficient of digital finance is 0.0435, slightly higher than the result of baseline regression, and still
significant at the level of 1%. Meanwhile, the coefficient and significance of other variables do not change significantly. Therefore, it can be considered that the previous conclusion is robust.

② Exclude the abnormal year: the P2P platform went bankrupt in 2018, which had a great impact on the development of digital finance. Therefore, this paper excludes that year and makes the regression again. The corresponding results are shown in Column (4). Among them, the coefficient of digital finance is 0.0366, which is significant at the level of 1%, basically consistent with the previous result. The above results show that the previous conclusions are robust and reliable.

4.3. Internal and External Mechanisms of Digital Finance Influencing Green Development.

4.3.1. Internal Mechanism. The Institute of Digital Finance Peking University measures the digital inclusive finance from the coverage breadth, depth, and digitization degree and then synthesizes these three indexes into the digital inclusive finance, which facilitates the research on its internal mechanism. Table 5 shows the regression results of the internal mechanism of digital finance. The results in Columns (1) and (2) demonstrate that the coverage breadth of digital finance has a positive influence on the green total factor productivity, and it is significant at the level of 1%, indicating that the “inclusive feature” of digital finance plays a significant role in the growth of green total factor productivity. Columns (3) to (6) present the results of the depth and digitization degree of digital finance. Their estimation coefficients are also positive, but they have not passed the statistical significance test, indicating that the depth and digitization degree of digital finance do not play a significant role in green growth. The above results suggest that the expansion of its coverage breadth promotes green development, but its depth and digitalization degree need to be further explored to better contribute to green development.

4.3.2. External Mechanism. The secondary industry mainly refers to the industrial sector. In the process of China’s rapid economic development, some industries, especially heavy industries, emit a large number of pollutants such as carbon dioxide and sulfur dioxide, which adversely affects the green and low-carbon development mode. According to the research of Xu Xianchun and others [23], the upgrading industrial structure promotes green development, and the promotion effect of digital finance on the industrial structure upgrading has been effectively verified. To test the role of the industrial structure upgrading, this paper refers to the research of Gan Chunhui and others, adopts the ratio of the tertiary industry to the secondary industry to express the industrial structure upgrading, and uses the mediating effect model to conduct the study [24].
Among them, the subscript $i$ indicates city identification and year identification. "indurs" indicates the mediating variable in this paper, the industrial structure upgrading. The definitions of other variables are consistent with the previous ones. For the mediating effect model, firstly, if the coefficient of $\alpha_1$ is significant and positive, it will be regarded as passing the test. In the second step, if the coefficient $\beta_1$ is significant and positive, it shows that digital finance can significantly affect the industrial structure upgrading. In the third step, if the coefficient $c_2$ is significant and positive, it means that it passes the mediating effect test. In addition, if only one of $\beta_1$ and $c_2$ passes the significance test, the bootstrap method is needed to perform the Sobel test.

Table 6 reports the results of external mechanism test. The coefficient of $\alpha_1$ is proved to be significant and positive, so they will not be elaborated here. In Column (2), the coefficient of digital finance (lndfi) is 0.1693, which is significant at the level of 1%, indicating that digital finance can significantly promote the urban industrial structure upgrading. The above results demonstrate that the industrial structure upgrading plays the mediating role in digital finance influencing urban green development. The coefficients of digital finance in the third Column are significant and positive. It suggests that there are other mediating roles, and the industrial structure upgrading bears part of the mediating roles. The rapid development of digital finance lowers the threshold for obtaining funds, and its information matching mechanism enables more small- and medium-sized enterprises to obtain funds, thus providing essential support for the upgrading and development of the tertiary industry, promoting the industrial structure upgrading and accelerating the process of urban green development. Thus, hypothesis 2 is verified.

### 4.4. Heterogeneity Analysis

#### 4.4.1. Heterogeneity of Region

Due to the huge differences in the economic and social development levels in different regions of China, there are great differences in resource endowments and development stages between the eastern region and other regions. Meanwhile, there are also great differences in their green development levels. In this context, this paper divides cities into eastern, central, and western cities to further explore the heterogeneity of the impact of digital finance on green development. The corresponding results are displayed in Column (1) and Column (2) of Table 7. It can be observed that the coefficient of digital finance in the eastern region is 0.0306, which is positive but not significant. The coefficient of digital finance in the central and western cities is 0.0390, which is positive and

\[
\text{ln} \text{Lnacf}_i = \alpha_0 + \alpha_1 \text{Lndfi}_i + \alpha_2 \text{controls}_i + \varphi_i + \pi_i + \epsilon_i \tag{2}
\]

\[
\text{indurs}_i = \beta_0 + \beta_1 \text{Lndfi}_i + \beta_2 \text{controls}_i + \varphi_i + \pi_i + \epsilon_i
\]

\[
\text{Lngtp}_i = \gamma_0 + \gamma_1 \text{Lndfi}_i + \gamma_2 \text{indurs}_i + \gamma_3 \text{controls}_i + \varphi_i + \pi_i + \epsilon_i
\]
significant at the level of 1%, indicating that the digital financial development in the central and western cities enhances the level of urban green development. This is consistent with the conclusion of the previous internal mechanism test that digital finance mainly plays a role in increasing the green total factor productivity through its inclusive feature. The reason why it does not have a significant role in the eastern region may be that the traditional finance there is developed enough to meet the supply of factors that promote green growth. Moreover, in the first Column, the coefficient of traditional finance is positive, which is also proved by the fact that it is significant at the level of 1%.

### Table 6: External mechanism of digital finance influencing green development.

|        | (1) Lngtfp       | (2) Lngtfp       | (3) Lngtfp       |
|--------|-----------------|-----------------|-----------------|
| Lnfdi  | 0.0377***       | 0.1693***       | 0.0356***       |
|        | (0.0111)        | (0.0564)        | (0.0111)        |
| Indurs |                 |                 | 0.0123***       |
|        |                 |                 | (0.0045)        |
| Lnpgdp | −0.0079         | −0.4208***      | −0.0027         |
|        | (0.0053)        | (0.0576)        | (0.0054)        |
| Edu    | 0.0065***       | 0.0162          | 0.0063***       |
|        | (0.0022)        | (0.0132)        | (0.0022)        |
| Lnurban| 0.0488***       | 0.1528*         | 0.0469***       |
|        | (0.0128)        | (0.0897)        | (0.0124)        |
| Fdi    | 0.0984          | 0.4020          | 0.0935          |
|        | (0.0804)        | (0.4625)        | (0.0805)        |
| Finance| 0.0061***       | 0.0573*         | 0.0054***       |
|        | (0.0018)        | (0.0311)        | (0.0017)        |
| _Cons  | −0.3572***      | 3.6666***       | −0.4023***      |
|        | (0.1016)        | (0.7295)        | (0.1015)        |
| Year fe| Yes             | Yes             | Yes             |
| City fe| Yes             | Yes             | Yes             |
| N      | 2574            | 2574            | 2574            |
| _R²    | 0.7312          | 0.8982          | 0.7322          |

### Table 7: Heterogeneity of digital finance influencing green development.

|        | (1) Eastern cities | (2) Central and western cities | (3) Large-scale cities | (4) Small-scale cities |
|--------|--------------------|-------------------------------|------------------------|------------------------|
| Lngtfp | 0.0306             | 0.0390***                    | 0.0349*                | 0.0418***              |
|        | (0.0208)           | (0.0143)                     | (0.0169)               | (0.0160)               |
| Lnfdi  | 0.0029             | −0.0107                      | −0.0073                | −0.0090                |
|        | (0.0088)           | (0.0073)                     | (0.0083)               | (0.0074)               |
| Lnpgdp | 0.0098**           | 0.0050*                      | 0.0108***              | −0.0017                |
|        | (0.0039)           | (0.0027)                     | (0.0027)               | (0.0036)               |
| Edu    | 0.0386             | 0.0484***                    | 0.0629***              | 0.0356                 |
|        | (0.0438)           | (0.0136)                     | (0.0183)               | (0.0224)               |
| Lnurban| 0.0136             | 0.1744*                      | 0.0445                 | 0.1717                 |
| Fdi    | 0.1405             | 0.0932                       | 0.1060                 | (0.1231)               |
| Finance| 0.0184***          | 0.0049***                    | 0.0057*                | 0.0075***              |
|        | (0.0070)           | (0.0017)                     | (0.0032)               | (0.0022)               |
| _Cons  | −0.4221            | −0.3131***                   | −0.4866***             | −0.2542*               |
|        | (0.3088)           | (0.1172)                     | (0.1545)               | (0.1461)               |
| Year fe| Yes                | Yes                          | Yes                    | Yes                    |
| City fe| Yes                | Yes                          | Yes                    | Yes                    |
| N      | 972                | 1602                         | 1286                   | 1286                   |
| _R²    | 0.7502             | 0.7186                       | 0.7275                 | 0.7387                 |

4.4.2. Heterogeneity of City Size. According to the median of the population density in cities, this paper divides cities into large-scale cities and small-scale cities and further explores the heterogeneity. The corresponding results are shown in Columns (3) and (4) of Table 7. It can be seen that digital finance plays a significant role in promoting green development in both large-scale cities and small-scale cities. The difference lies in that the significance of digital finance in large-scale cities is only 5%, while that in small-scale cities is 1%. The coefficient of digital finance in small-scale cities is 0.0418, greater than 0.0349. Therefore, for small-scale cities, the significance and coefficient of digital finance prove that it can play a stronger role, which is also consistent with the
previous research findings that the inclusive feature of digital finance plays a significant role.

5. Conclusion
This paper attempts to explore the current situation of green development in Chinese cities from the perspective of green development and digital finance and further investigate how digital finance affects green development. In this paper, the panel data of 286 Chinese cities from 2011 to 2019 is employed. Moreover, the two-way fixed effect model, instrumental variable method, and mediating effect model are adopted for the empirical test. The main conclusions are as follows. First, digital finance can significantly improve the green development of Chinese cities. After using the number of telephones in 1984 as an instrumental variable and employing the robustness test method, such as winsorization, the conclusion is still robust and reliable. Second, digital finance promotes the green development level of Chinese cities through coverage breadth (internal mechanism) and industrial structure upgrading (external mechanism). Third, digital finance has a stronger effect on driving green development in the central and western cities, as well as small-scale cities.

Currently, there are few literatures on the relationship between digital finance and urban green development. This paper provides valuable empirical evidence for studying the relationship between them. Furthermore, this paper puts forward the following suggestions. First, we should vigorously explore its market depth and develop the digitalization degree. The breadth of digital finance plays a significant role in the green total factor productivity. However, the roles of depth and digitalization degree have not been highlighted. Hence, it is necessary to explore the role of digital finance and further reveal the green dividend brought by the development of digital finance. Second, we should put forward the policy of digital financial empowering the real economy according to local conditions. The central and western cities and small-scaled cities are the key beneficiaries of digital finance. Based on local resource endowments and production conditions, digital finance should play the role of empowering the real economy, speeding up the industrial structure upgrading, easing the financing constraints of enterprise development, reducing resource mismatch, and contributing to improving green development.

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

Conflicts of Interest
The authors declare that they have no conflicts of interest.

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