

Digital Financial Inclusion, Industrial Structure Upgrading and Green Technology Innovation

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Abstract: Based on inter-provincial panel data from 2011 to 2018, this article empirically analyzes the impact of digital financial inclusion, industrial structure upgrading and green technological innovation from the perspective of digital financial development. The research results show that: first, digital financial inclusion has a significant positive effect on green technology innovation; second, regional heterogeneity indicates that the promotion effect of digital financial inclusion on green technology innovation is higher in the central and western regions than in the eastern regions; Third, from the perspective of intermediary effects, the upgrading of industrial structure has a certain intermediary effect between digital financial inclusion and green technology innovation, and its role accounts for 8.16%. The research results of this paper have important policy implications for the promotion of green innovation and development of digital financial inclusion.

1. Introduction

The report of the Nineteenth National Congress of the Communist Party of China pointed out that taking technological self-reliance and self-reliance as the strategic support of national development and accelerating the promotion of green and low-carbon development, China's economy has turned to innovation-driven intensive growth. To seize the historic opportunity of the new round of technological revolution and industrial transformation, to promote the “green recovery” of the world economy in the new era, and to benchmark the goal of carbon neutrality, green technological innovation is the key. Based on this, this article deeply analyzes the impact of digital financial inclusion and green technology innovation from both theoretical and empirical aspects, which will help to fully understand the current quality of green development in China and provide policy recommendations for this.

2. Literature Review

At present, the research on digital financial inclusion, industrial structure upgrading, and green technology innovation can be roughly divided into three aspects. The first is the study of digital financial inclusion and industrial structure upgrading. For example, Cao Kaiyan and Yifei Fei et al. (2019) found that the development of digital financial inclusion and its three subdivision dimensions of coverage, depth of use, and digitization have significantly promoted the upgrading of industrial structure by constructing an individual fixed effect model; 2. It is the study of digital financial inclusion and green technology innovation. For example, Zhang Xiaodan and Peng Geng (2021) found that the development of digital financial inclusion and its three subdivision dimensions of coverage, depth of use and degree of digitization have significantly promoted regional innovation capabilities through the construction of a fixed effect model and a threshold model; three It is the study of industrial structure upgrading and green technology innovation. For example, Zhu Yuke, Gao Guihong, and Xiao Tian (2021) found that the rationalization and advancement of industrial structure has a significant sectoral mediating effect between the green technological innovation of industrial enterprises and the high-quality economic development by constructing an intermediary effect model and a panel threshold regression model. Many studies focus on the relationship between digital financial inclusion, industrial structure upgrading, and green innovation development, while the relationship between the three is rarely explored under the unified analysis framework. This article explores the interrelationship between digital financial inclusion, industrial structure upgrading and green technology innovation by constructing an intermediary effect model.

3. Models, Variables and Data

3.1 Variable Selection

Explained variable: Green technology innovation (gtfp). Since there is no unified standard for the measurement of green technology innovation at home and abroad, this article uses DEAP2.1 software, adopts the research of Yang Haochang, Li Lianshui, and Zhang Invention (2020), and considers unexpected The output Super-SBM model measures green technological innovation. The selection of required input and output indicators and data processing are as follows.

Investment indicators are analyzed from two dimensions of R&D capital investment and R&D labor input. R&D capital investment This article refers to the research of Liang Shengrong and Luo Liangwen (2019), and selects the R&D capital stock in each region to measure. The calculation method is based on 2005 at a constant price, using the “perpetual inventory method” to calculate; R&D labor input in this article Measured by the indicator of full-time equivalent of R&D personnel in various provinces and cities.

Output indicators include two aspects: expected output and undesired output. The expected output adopts the research of Wang Hui, Wang Shuqiao, Miao Zhuang, and Li Xiaocong (2016), and selects the two indicators of the number of R&D effective invention patents in each region and the sales revenue of new products to measure; the undesired output mainly examines the environmental issues of technological innovation , Adopting the research of Lu Yanwei, Xie Yanxiang, Lou Xianjun (2020), the total amount of industrial wastewater discharge and industrial discharge are selected to measure the environmental pollution caused by the technological innovation activities of enterprises in various regions.

Explanatory variables: The core explanatory variables of this article are the digital financial inclusion index (inf_t) and its three-dimensional sub-items: digital degree index (inf_di), depth of use index (inf_de) and breadth of coverage index (inf_br). The data comes from the Peking University Digital Financial Inclusive Index released by the Peking University Digital Finance Research Center.

Intermediary variables: industrial structure upgrading (isu_{it}). Industrial structure upgrading is a process of effective resource allocation. In this process, resource elements are continuously transferred from low-productivity sectors to high-productivity sectors to achieve optimal utilization of resources. Using the research of Han Keyong and Meng Weifu (2021), construct the industrial structure upgrading index of each region. The specific calculation method is as follows:

$$isu_{it} = \sum V_{ijt} \times LP_{ijt}$$

Among them, i is the area, j is the industry category, and t is the year. V_{ijt} represents the proportion of industry j in the region i in year t to the gross product (GDP) of the region; LP_{ijt} is the labor productivity of industry j in region i in the t year, obtained by using the ratio of the value-added of industry j to the number of employees.

Control variables: The level of economic development (\ln_gdp). The better the regional economic development level, the higher the activity of capital and the stronger the vitality of innovation and entrepreneurship, which in turn can actively promote the development of green technology innovation. This article uses the logarithm of the per capita gdp in each region. Enterprise scale (es), as an important subject of technological innovation, the critical scale of an enterprise determines its advantages, capabilities and motivation for technological innovation. This paper adopts the research of Zhao Lu, Gao Honggui, and Xiao Quan (2021) to calculate the ratio of main business income to the total number of enterprises. Foreign direct investment (fdi), the influx of foreign capital and technology, can make up for the funding gap in domestic technological innovation and the technology spillover effect brought about will affect the technological progress of regional enterprises. This paper selects the proportion of foreign direct investment (fdi) in GDP to express. Human capital (hc), another important subject of scientific research innovation is human capital. The higher the level of education, the better the quality of scientific research personnel, which is more conducive to social innovation. This article uses the ratio of scientific research personnel to the number of employed people to calculate.

3.2 Model Establishment

In order to study the relationship between digital financial inclusion, industrial structure upgrading and green innovation, this paper constructs the following empirical model.

One is to analyze the empirical relationship between digital financial inclusion and green innovation on the basis of control variables: $gtfp_{it} = \alpha + \beta * inf_{it} + \gamma_i * control_i + \varepsilon_{it}$ (1)

Second, in order to further test the mediating effect of industrial structure upgrading between digital financial inclusion and green innovation, this paper constructs the following stepwise regression model:

$$gtfp_{it} = \alpha_1 + \beta_1 * inf_{it} + \gamma_i * control_i + \varepsilon_{it} \quad (2)$$

$$isu_{it} = \alpha_2 + \beta_2 * inf_{it} + \gamma_i * control_i + \varepsilon_{it} \quad (3)$$

$$gtfp_{it} = \alpha_3 + \beta_3 * inf_{it} + \theta_3 * isu_{it} + \gamma_i * control_i + \varepsilon_{it} \quad (4)$$

3.3 Data Sources and Descriptive Statistics

This article selects 30 provinces and cities in China from 2011 to 2018 (considering the availability of data, except for Hong Kong, Macao, Taiwan and Tibet) as the research sample to analyze the relationship between digital financial inclusion, industrial structure and green technology innovation, and various indicators. The data comes from the “China Statistical Yearbook”, “China Science and Technology Statistical Yearbook”, “China City Statistical

Yearbook”, “China Environment Statistical Yearbook” and statistical yearbooks of various provinces and cities over the years.

Descriptive statistical analysis of related variables in the text: The maximum value of the digital financial inclusion index is 377.73, the minimum value is 18.33, the average value is 188.18, and the standard deviation is 84.97, indicating that there are differences in the development level of digital financial inclusion in China, showing the characteristics of polarization. The coverage, depth and degree index also showed the same characteristics.

Second, the maximum value of the regional green innovation efficiency is 1.2065, the minimum value is 0.1311, the average value is 0.5914, and the standard deviation is 0.2207, indicating that the gap between the green innovation capabilities of various provinces across the country is still large, and the green innovation efficiency is still low. There is a lot of room for improvement.

4. Empirical Analysis

4.1 Correlation Analysis

In order to avoid the multicollinearity of each variable in the regression analysis, this paper firstly carried out the correlation analysis results of the variables as shown in Table 1. It can be seen from the data in the table that the correlation coefficients of most variables are less than 0.4, which indicates that there is a weak correlation between the variables, that is, there is no multicollinearity between the variables.

Table 1 Correlation Analysis

| Variable | gftp | inf_g | isu | Ln_gdp | fdi | es | hc |
|----------|---------|--------|--------|--------|---------|---------|--------|
| gftp | 1.0000 | | | | | | |
| inf_t | 0.3921 | 1.0000 | | | | | |
| isu | 0.4741 | 0.4824 | 1.0000 | | | | |
| ln_gdp | 0.4873 | 0.5159 | 0.9703 | 1.0000 | | | |
| fdi | 0.3856 | 0.0529 | 0.1343 | 0.1373 | 1.0000 | | |
| es | -0.2542 | 0.1823 | 0.2430 | 0.2446 | -0.0799 | 1.0000 | |
| hc | 0.6127 | 0.2209 | 0.3953 | 0.4027 | 0.3437 | -0.4724 | 1.0000 |

5.2 Regression Analysis of Green Technology Innovation

It can be seen from the fitting results of model (1) in Table 2 that digital financial inclusion (The estimated coefficient of inf) is 0.0005586, which is significant at the 1% significance level, which indicates that the implementation of digital financial inclusion policies can significantly enhance green innovation. The fitting results of models (2)-(4) show that the estimated values of the three variable coefficients of digital financial inclusion (inf_br), depth of use (inf_de), and digitization degree (inf_di) are 0.0005791, 0.0005976, and 0.0002752, respectively. Both are significant at the 1% significance level. From a dimensional perspective, the coverage, depth of use, and degree of digital financial inclusion have significantly promoted green innovation, and the depth of use of digital financial inclusion has the greatest impact on it, followed by coverage, and the degree of digitization has the least impact.

Table 2 the Impact Of Digital Financial Inclusion on Green Technology Innovation

| Variable | (1) | (2) | (3) | (4) |
|-----------------------------------|----------------------------|--------------|-----|-----|
| Digital Financial Inclusion Index | 0.0005586*** (0.000946) | | | |
| Digital financial inclusion | | 0.0005791*** | | |

| | | | | |
|---|---------|------------|----------------------------|-----------------------------|
| breadth | | (0.000994) | | |
| Depth of Digital Inclusive Amount Use | | | 0.0005976*** (0.000975) | |
| Digital degree of digital financial inclusion | | | | 0.0002752*** (0.0000629) |
| Control variable | control | control | control | control |
| Constant term | | | | |
| Individual fixed effect | control | control | control | control |
| Year fixed effect | control | control | control | control |
| F statistic P value | 0.000 | 0.000 | 0.000 | 0.000 |
| R ² | 0.2373 | 0.2346 | 0.2458 | 0.1841 |

4.3 Analysis of the Mediating Effect of Green Technological Innovation

After analyzing the role of digital financial inclusion in promoting green technology innovation and the differences in regional effects, in order to investigate whether digital financial inclusion has an effect on green technology innovation by affecting the upgrading of industrial structure, this paper further selects industrial structure upgrading (isu) as The mediation variables were tested for mediation effect, and the results are shown in Table 3. The first step of the intermediary effect model examines the overall impact of digital financial inclusion on green technology innovation. It is consistent with the regression model (1). The coefficient of influence of digital financial inclusion is significantly positive, indicating that digital financial inclusion has a significant impact on green innovation. The regression coefficient is 0.000558; the second step is to test the influence of digital financial inclusion on the industrial structure. The results show that the coefficient of influence of digital financial inclusion on the upgrading of industrial structure is 0.01667, and it has passed the 1% significance level. The test shows that digital financial inclusion can significantly improve the upgrading of industrial structure; the third step is to test the impact of digital financial inclusion and industrial structure upgrading on green technological innovation. From the regression results, it can be seen that the industrial structure upgrading of the intermediary variable has a significant effect on green innovation. The regression coefficient is 0.002737, and the digital financial inclusion coefficient is 0.000513, which is lower than the 0.000559 in the first part, indicating that the mediation effect of industrial structure upgrading in the process of digital financial inclusion in promoting green technology innovation is part of the existence of digital financial inclusion. Inclusive finance is a key element to promote green technological innovation. Among them, the mediation effect accounts for 8.16%, which means that 8.16% of the impact of digital financial inclusion on green innovation is achieved through the upgrading of the industrial structure. Furthermore, from the three-dimensional analysis results of digital financial inclusion, the degree of digitalization is the main driving force for the transformation and upgrading of industrial structure to improve green innovation. In addition, this article uses the Slobe test to perform robustness testing, and the results show that the Z value is 3.477 and the P value is 0.000508, which is significant, indicating that the test result of the mediating effect is robust.

Table 3 the Intermediary Effect of Green Technological Innovation

| variable | Digital Financial Inclusion Index | | | Digital degree of digital financial inclusion | | |
|-----------------------------|-----------------------------------|-----------------------------|-----------------------------|---|-----------------------------|-----------------------------|
| | first step | Second step | third step | first step | Second step | third step |
| Green technology innovation | 0.0005586*** (0.0000946) | | 0.000513*** (0.0001157) | 0.0002752*** (0.0000629) | | 0.00021*** (0.0000695) |
| Mediating variable | | 0.0166708*** (0.0016572) | 0.0027366*** (0.0039844) | | 0.0082415*** (0.0011673) | 0.0079095*** (0.0037246) |

| | | | | | | |
|-------------------------|-----------|----------|-----------|-----------|----------|----------|
| Control variable | control | control | control | control | control | control |
| Constant term | 0.5151627 | 6.530162 | 0.4972925 | 0.4768901 | 5.392372 | 0.434239 |
| Individual fixed effect | control | control | control | control | control | control |
| Year fixed effect | control | control | control | control | control | control |
| R ² | 0.2373 | 0.5847 | 0.2391 | 0.1841 | 0.5014 | 0.2017 |
| Mediation effect | 8.16% | | | 23.68% | | |

5. Conclusions and Recommendations

Based on the above empirical analysis results, in order to better promote China's green innovation and achieve high-quality economic development, this article puts forward the following policy recommendations:

First, continue to expand the depth of digital financial inclusion, and vigorously play a role in promoting green innovation. It is necessary to vigorously expand the reach and service depth of digital inclusive finance, vigorously develop emerging technologies such as big data, artificial intelligence, and blockchain, strengthen the advantages of digital technology, effectively reduce the threshold and cost of financial services, and eliminate geographic and physical Restrictions on outlets and business hours have continuously improved the efficiency and scope of financial services, thereby realizing the continuous development of green innovation.

Second, strengthen support for inclusive finance in the central and western regions, and promote green and innovative development to achieve “curve overtaking”. China should implement a regionally differentiated development strategy for inclusive finance, increase support for inclusive finance in the central and western regions, and continue to promote the continuous development of green innovation. At the same time, all regions should continue to strengthen financial policy support, plan inclusive financial development strategies in the region according to local conditions, and encourage various financial institutions to increase innovation in digital financial products by optimizing the business environment in the region and providing tax reductions and exemptions. Intensive efforts, focusing on small and medium-sized enterprises, to promote the faster development of digital financial inclusion. The central and western regions should seize the national policy on “Chengdu-Chongqing Joint Construction of Western Financial Center Planning”, strengthen the driving role of Chongqing and Chengdu's central cities, promote the rational flow and efficient agglomeration of various financial factors and resources, and support Chongqing to build a western financial center. Under the opportunity of accelerating Chengdu-Chongqing's joint construction of the western financial center, the central and western regions should take the initiative to actively integrate into the western financial center.

Third, promote the transformation and upgrading of the industrial structure, and effectively enhance the transmission capacity of green innovation. China must increase reform and innovation, based on basic research and development, independent innovation, improve the level of science and technology, accelerate the development of strategic emerging industries, strengthen overall planning, focus on accelerating the formation of leading and pillar industries, and effectively enhance the core of the industry. Competitiveness, solve the problem of industrial development, improve the economic efficiency of the industry as the core task, and focus on the implementation of major breakthroughs with advantageous resources as the main path to promote the integration, clustering, and ecological development of strategic emerging industries. It is necessary to accelerate the implementation of the country's various fiscal, taxation, and financial preferential policies for

accelerating the cultivation and development of strategic emerging industries, increase capital investment, rely on leading enterprises, and continuously improve mechanisms to promote chip, advanced equipment manufacturing, biomedicine, etc.

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