New Exploration of Industrial Structure Upgrading under the Wave of Digital Finance

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Abstract. Based on the panel data of cities in the Yangtze River Delta region from 2011 to 2021, Through the two-way fixed effect model, this paper explores the mechanisms, effects and heterogeneity of digital finance development in promoting the upgrading of industrial structure. The results show that digital finance can significantly promote the upgrading of industrial structure, among which innovation and entrepreneurship is an important transmission path, and technology and finance play a key role in the process. Heterogeneity analysis shows that in non-central cities and cities with high consumption level, the promotion effect of digital finance development on industrial structure upgrading is more obvious. Therefore, it is necessary to further strengthen the construction of digital financial infrastructure, build an innovation-driven entrepreneurial environment, promote, and optimize the consumption environment according to city conditions.

Keywords: digital finance; upgrading of industrial structure; mediation effects; fixed effect model.

1. Introduction

At present, the Chinese economy has shifted to a stage of high-quality development. The Central Economic Work Conference emphasized the expansion of domestic demand, the independent capacity of industrial and supply chains, and the capacity of independent innovation to promote the optimization and upgrading of the industrial structure. As a region with developed economy and remarkable innovation vitality, the Yangtze River Delta region has an economic aggregate of nearly 29 trillion yuan, accounting for nearly one quarter of the national GDP, injecting strong vitality into China's economic development [1] With the rapid development of digital finance, how to promote the upgrading of its industrial structure in the Yangtze River Delta region has become a key issue. As an emerging financial business model, digital finance enables investment, financing, payment and other fields through the Internet and information and communication technology. Despite its profound impact, the research is still in its infancy.

Based on the panel data of the Yangtze River Delta city from 2011 to 2021, this paper studies the impact of digital finance on the upgrading of industrial structure through the two-way fixed-effect model. The contributions are: introducing the concepts of "innovation and entrepreneurship" and "technology finance" to broaden the research scope; make use of the Internet and mobile phone penetration rate to solve the endogenous problems, ensure the steady and reliable conclusion; conduct the heterogeneity test for different city characteristics, deeply explore the differentiated impact of digital finance on industrial upgrading, and provide strong support for policy making [2].

2. Theoretical analysis and research hypothesis

As the modernization and digital upgrading of traditional finance, the influence of digital finance has penetrated into all levels of the financial market [3]. Through the universality of resource coverage, the speed of data dissemination and the convenience of information sharing, digital finance effectively solves the problem of information asymmetry between lenders and borrowers, reduces the cost of financial transactions and services, optimizes the allocation of financial resources, expands the scope of services, and significantly improves the efficiency of financial services. This comprehensive optimization not only provides efficient and convenient financial services for small, medium and micro industries and urban and rural low-income groups, but also injects new impetus into the vigorous development of emerging industries, and strongly promotes the upgrading of

industrial structure and sustained economic growth of [4]. Therefore, the following assumptions are proposed:

H1: The development of digital finance can promote the upgrading of the industrial structure.

With its accurate market analysis, customer demand assessment and risk control ability, digital finance not only enhances the market risk management ability, but also provides a broader space and opportunities for innovation and entrepreneurship activities. It makes up for the shortage of traditional finance in the operating space and time, lowers the access threshold of financial services, enables enterprises to obtain financial support more conveniently and at a low cost, and then promotes the expansion and mature of innovation and entrepreneurship activities [5] . In addition, digital finance also highlights the fairness of financial services and promotes the equalization of entrepreneurial opportunities. Especially for innovation subjects, such as small, medium and micro enterprises, digital finance improves its financing efficiency and reduces risks, and further stimulates the entrepreneurial ability and enthusiasm of residents. The prosperity of innovation and entrepreneurship activities has driven the development of science and technology, and promoted the deep integration of finance and technology. With the support of fintech, digital finance has provided in-depth digital services for all demand sides of the industrial chain, further improves the efficiency of financial resource allocation, and actively promotes the upgrading of industrial structure in [6]. Therefore, the following assumptions are proposed:

H2: The development of digital finance will help to improve the level of innovation and entrepreneurship and thus promote the upgrading of the industrial structure.

3. Study design

3.1. Description of Variables

(1) Explanatory variable: Industrial structure upgrading index (w)

After comparison, this paper draws on the research methods of Fu Linghui and Cheng Qiongwen to construct the following industrial structure upgrading index: firstly, according to the division of the three industries, the GDP is divided into three parts, and the proportion of the added value of each part in GDP is taken as a component of the space vector, so as to construct a set of three-dimensional vectors $X_0=(x_{1,0}, x_{2,0}, x_{3,0})$,and then calculate the vectors X0 and $X_1=(1, 0, 0)$, $X_2=(0, 1, 0)$, $X_3=(0, 0, 1)$ respectively θ_j(j=1,2,3), and the level of industrial structure upgrading is measured by giving different weights. This index also reflects the degree of change and the direction of change of industrial structure, when the greater the w value, indicating that the higher the level of industrial structure upgrading.

$$\theta_j = \arccos\left(\frac{\sum_{i=1}^{3} x_{i,j}\cdot x_{i,0}}{(\sum_{i=1}^{3}(x_{i,j}^2)^{1/2}\cdot\sum_{i=1}^{3}(x_{i,0}^2)^{1/2})}\right) \quad j=1, 2, 3 \tag{1}$$

$$w = \sum_{k=1}^{3}\sum_{j=1}^{k}\theta_j \tag{2}$$

(2) Explanatory variable: Digital Financial Development Index (LNIND).

This paper selects the city-level digital inclusive finance index released by the Center for Digital Finance of Peking University to evaluate the development of digital finance. The index constructs a complete set of comprehensive indicators of digital finance from the three dimensions of coverage breadth (LNBRE), depth of use (LNDEP) and degree of digitalization (LNDIG).

(3) Intermediary variable: level of innovation and entrepreneurship (LNINN)

This paper uses the China Regional Innovation and Entrepreneurship Index released by Peking University to measure the level of urban innovation and entrepreneurship, which covers a wide range

of enterprises, especially those micro, small and medium-sized enterprises that are supported in the field of digital finance, have a high degree of entrepreneurial activity, specialization, refinement, specialization and novelty, and can more comprehensively reflect the innovation and entrepreneurship vitality of different regions.

(4) Control variables

Referring to the research of Tang Jiqiang [7], Du Jinmin [8], the following control variables are selected to enhance the explanatory power of the model: urbanization level (UR), which is measured by the proportion of urban permanent population in the total permanent population; The level of opening up to the outside world (open) is measured by the ratio of total imports and exports of goods to GDP; the degree of government intervention (GOV), which is measured as the ratio of the amount of foreign capital actually used (converted into RMB) to GDP; The level of human capital (PEO) is measured by the proportion of the number of students enrolled in the general undergraduate and junior colleges in the region to the number of permanent residents; The level of social consumption (con) is measured by the ratio of total retail sales of consumer goods to GDP.

3.2. Sample Selection and Data Sources

This paper selects the statistical data of 41 cities in the Yangtze River Delta region from 2011 to 2021 to measure the values of various indicators. The data are from the China City Statistical Yearbook, the statistical yearbooks of each city, and the Statistical Development Bulletin. For some of the missing data, the linear interpolation method is used to supplement them.

3.3. Model Building

In order to empirically explore the specific impact of the development of digital finance on the upgrading of industrial structure, this paper constructs the following model:

$$w_{it} = \alpha_0 + \alpha_1 \ln ind_{it} + \alpha_n controls_{it} + \upsilon_i + \lambda_t + \varepsilon_{it} \quad (3)$$

Among them, i and t represent the city and year respectively, the explanatory variable w_{it} represents the level of industrial structure upgrading of city i in year t, the core explanatory variable $lnind_{it}$ represents the level of digital financial development of city i in year t, and $controls_{it}$ is the selected control variable, υ_i is the individual fixed effect , λ_t is the time fixed effect, ε_{it} represents the random perturbation term.

4. Analysis of empirical results

4.1. Descriptive Statistics

Stata 18.0 software was used to perform descriptive statistics on each variable, and the specific results are shown in Table 1. As shown in Table 1, the standard deviation of the degree of digitalization (LNDIG) is significantly larger than the standard deviation of the breadth of digital finance coverage (LNBRE) and depth of use (LNDEP) and is the largest standard deviation among the statistical variables, indicating that the difference in the degree of digitalization is greater than the difference in the breadth of coverage and the depth of use between regions, which may be because the degree of digitalization covers a wider range of factors, such as technology infrastructure, digital literacy, policy support, etc., which may vary more between different regions. Table 2 shows the results of the multicollinearity test of the variables, the VIF value is less than 5 and the Mean VIF value is less than 2, indicating that there is no significant collinearity between the variables.

Table 1. Descriptive statistics

variable	Number of samples	average value	standard deviation	minimum	maximum
w	451	6.705	0.307	5.863	7.498
lninn	451	2.753	1.665	-1.646	7.170
lnind	451	5.222	0.483	3.299	5.885
lnbre	451	5.179	0.503	2.660	5.918
lndep	451	5.263	0.435	3.723	5.870
lndig	451	5.216	0.711	2.250	6.082
ur	451	0.616	0.120	0.313	0.905
open	451	0.027	0.018	0.000	0.093
gov	451	0.166	0.062	0.076	0.356
peo	451	0.021	0.022	0.001	0.127
con	451	0.397	0.090	0.198	0.726

Table 2. Multicollinearity test

variable	lnind	ur	open	gov	peo	con	Mean VIF
VIF	1.662	3.125	1.806	1.708	1.472	1.101	1.812
1/VIF	0.602	0.32	0.554	0.585	0.68	0.908	

4.2. Baseline Regression

After strict screening of F-test, Haussmann test and LM test, it was finally decided to use the two-way fixed-effect model (controlling for both regional and temporal effects) as the best estimation model. Table 3 presents the benchmark regression results of the impact of digital finance development on industrial structure upgrading, in column (1) without the addition of control variables, and the addition of control variables in column (2), the impact coefficients of both digital finance (lnind) are significantly positive at the 1% confidence level, which indicates that the development of digital finance can promote the upgrading of industrial structure, and the hypothesis H1 is true.

Table 3. Baseline regression results

	(1)	(2)	(3)	(4)	(5)
variable	w	w	w	w	w
lnind	0.470***	0.289***			
	(0.0485)	(0.0451)			
lnbre			0.181***		
			(0.0244)		
lndep				0.233***	
				(0.0613)	
lndig					-0.0463**
					(0.0215)
region	control	control	control	control	region
Constant	5.171***	5.449***	5.936***	5.515***	6.704***
	(0.209)	(0.196)	(0.127)	(0.284)	(0.135)
region	control	control	control	control	control
Time	control	control	control	control	control
Observations	451	451	451	451	451
R-squared	0.957	0.969	0.970	0.967	0.966

Note: The numbers in parentheses are robust standard errors, ***p<0.01, **p<0.05, *p<0.1;

4.3. Robustness test

(1) Change is measured by explanatory variables

The specific calculation formula is as follows:

$$upg = \sum_{i=1}^{3} y_i * i = y_1 + y_2 * 2 + y_3 * 3 \quad (4)$$

In Eq. (4), UPG represents the industrial structure upgrading index, and Yi represents the proportion of the added value of the ith industry in GDP. The index reflects the upgrading relationship between the three types of industries, and the higher the value of UPG, the higher the level of development of the industrial structure. The regression results of column (1) in Table 4 show that the regression coefficient of industrial structure upgrading (UPG) is 0.105, which is significantly positive at the 1% level, indicating that the conclusion of H1 is stable.

(2) Explanatory variables are tail-shrunk

The purpose of this step is to improve the accuracy and robustness of the results by shrunken at the 1% level of the explanatory variable numerical financial indicators and regression analysis. The regression results of column (2) in Table 4 show that the regression coefficient of digital finance (w) is 0.321, which is significantly positive at the 1% level, indicating that the H1 conclusion is still robust.

(3) Change the sample range

The change in the sample scope mainly involves the following two aspects: first, referring to the practice of Jiang Hongli [9], 2013 was recognized as the first year of China's digital finance development, which marked that China's digital finance industry has entered a stage of rapid growth, so in order to conduct a robustness test, the time range was changed to 2013 to 2021. Second, the regression results of columns (3) to (4) in Table 4 showed that the regression results were significantly positive at the 1% level, indicating that the H1 conclusion was still robust.

Table 4. Robustness test

	(1)Change the explanatory variable	(2)Explanation variable shrinkage	(3)Replace the time period	(4)Municipalities directly under the central government and provincial capitals are excluded
variable	upg	w	w	w
lnind	0.105***	0.321***	0.444***	0.305***
	(0.0194)	(0.0561)	(0.118)	(0.0474)
Control variables	control	control	control	control
region	control	control	control	control
Time	control	control	control	control
Constant	1.992***	5.300***	4.473***	5.114***
	(0.0839)	(0.236)	(0.594)	(0.195)
Observations	451	451	369	407
R-squared	0.965	0.969	0.965	0.960

4.4. Mediator effect test

In previous studies, the stepwise test proposed by Wen Zhonglin [10] has often been used to analyze the mediating effect, but this method may have problems of weak statistical power and estimation bias. In view of this, this paper follows the research idea of Jiangzhou and uses the causal inference method to verify the mediation effect, and the test scheme focuses on equations (5) and (6) of the stepwise test method, rather than equation (7).

$$w_{it} = \alpha_0 + \alpha_1 \ln ind_{it} + \alpha_n controls_{it} + \upsilon_i + \lambda_t + \varepsilon_{it} \quad (5)$$

$$lninn_{it} = \beta_0 + \beta_1 \ln ind_{it} + \beta_n controls_{it} + \upsilon_i + \lambda_t + \varepsilon_{it} \quad (6)$$

$$w_{it} = \gamma_0 + \gamma_1 \ln ind_{it} + \lambda_2 \ln inn_{it} + \gamma_n controls_{it} + \upsilon_i + \lambda_t + \varepsilon_{it} \quad (7)$$

In model (6), $lninn_{it}$ represents the level of innovation and entrepreneurship of city i in period t.

On the basis of the previous analysis, this study focuses on equation (6) in the empirical analysis, and the specific results are detailed in Table 6. Column (2) in Table 6 shows that the coefficient of digital finance development on the level of innovation and entrepreneurship is 0.562, and it is significant at the 1% confidence level, which means that every bit of progress in digital finance can bring about a significant improvement in the level of innovation and entrepreneurship. Moreover, the data from columns (2) to (5) provide further evidence of the stability of this effect, and the significant positive effects of digital finance persist even after robustness tests. In order to ensure the robustness of the results, the model was tested using the bootstrap method, which combined the maximum likelihood estimation and bias-corrected bootstrap technique to obtain the confidence interval of the parameter estimate.

Table 5. Results of the mediation mechanism test

	(1)	(2) Replace the time period	(3) Municipalities directly under the central government and provincial capitals are excluded	(4) lnind lags by one period	(5) IV: lnnet lnmob
variable	lninn	lninn	lninn	lninn	lninn
lnind	0.562***	0.627*	0.414***		1.273**
	(0.150)	(0.321)	(0.152)		(0.612)
L.lnind				0.584***	
				(0.142)	
Control variables	control	control	control	control	control
region	control	control	control	control	control
Time	control	control	control	control	control
Constant	1.578**	1.060	1.021	1.717***	-0.964
	(0.648)	(1.615)	(0.626)	(0.644)	(2.588)
Observations	451	369	407	410	451
R-squared	0.989	0.991	0.986	0.990	0.988

5. Conclusion and suggestion

Based on the data of the Yangtze River Delta from 2011 to 2021, it is found through model analysis that digital finance significantly promotes the upgrading of industrial structure, and innovation and entrepreneurship and technology finance are the key factors. Non-central cities and high-consumption cities benefit more significantly. Based on the above study findings, the following suggestions are proposed:

(1) The Yangtze River Delta region should promote the multi-dimensional construction of digital finance, grasp the opportunity of "new infrastructure", strengthen technical support based on 5G, industrial Internet, cloud computing and big data, promote financial knowledge, improve the understanding and application of digital finance by economic participants, and promote the popularization and deepening of digital finance; financial regulation also needs to constantly adapt and innovate to ensure the stability of the financial market.

(2) The Yangtze River Delta region should take digital finance as an opportunity, take innovation-driven as the core, optimize the policy environment, increase financial subsidies, tax incentives and financial support for technological enterprises, and encourage financial institutions to allocate more resources to technology-based enterprises with real innovation ability and growth potential; build intelligent risk decision system through financial technology to reduce risks and attract more funds into scientific and technological innovation.

(3) Central cities should encourage and support the deep integration of finance and the real economy, and the cross-border integration with emerging technologies such as the Internet. By establishing multi-field cooperation platform and promoting coordinated development, the industrial structure upgrading of central cities can be further enhanced.

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