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Research on the Development and Influence on the Real Economy of Digital Finance: The Case of China

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Abstract: Based on the panel data of 31 provinces in China from 2011 to 2020, this paper analyzes the development status and distribution characteristics of digital finance, and studies the impact of digital finance on the growth of the real economy. First, whether China's digital finance development can be classified by region through quartile images is investigated, and whether there are differences in the development of digital finance between regions and within regions is explored. Then, the dynamic characteristics of regional digital finance development distribution are analyzed by kernel density estimation, and the regression model is constructed to analyze the effect of digital finance development on promoting the growth of the real economy. The numerical result shows that the development characteristics of digital finance are different between regions and within regions, and the development of digital finance can significantly promote the growth of the real economy.

Keywords: digital finance; real economy; kernel density estimation; quantile regression

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1. Introduction

The integrated development of digitalization and informationization has promoted the process of informationization in the world. China is promoting the digital economy and making every effort to build a "digital China". In addition, digital informatization transforms traditional finance into digital finance, which creates the conditions for the development of digital finance. Compared with traditional finance, digital finance is a financial development method combined with internet information technology, using digital technologies such as big data, blockchain, cloud computing, artificial intelligence, etc. Digital finance has obvious advantages in user experience and service accuracy, which greatly reduce financial transaction costs, facilitate payment methods, improve the efficiency of financial services, and expand the coverage of financial services. Digital finance enriches the content of financial services and provides innovations in financing for small- and medium-sized enterprises (SMEs).

Due to COVID-19, the world's economic pattern has undergone tremendous changes. Digital finance is not limited by time and space, and can continue to play its unique role even during the pandemic; thus, digital finance can help accelerate economic recovery. As we know, the basis for the stable operation of the national market is the real economy, so the relationship between the real economy and finance is the basic relationship that must be resolved in the development of the world economy today. Digital finance, internet finance, and financial technology are improvements of traditional finance, and their core attributes are inclusive and accurate financial services. That is, digital finance is a broad derivative of digital inclusive finance. The origin of digital finance is still finance, and it should highlight its own characteristics, actively serve the rapid development of the real economy, guide the economy "from virtual to real", and accelerate the promotion of high-quality economic development.

With the advancement of internet digital technology, digital finance has developed rapidly. Arjunwadkar [1] showed that, different from the traditional financial service

model, digital finance generated a large amount of data based on the internet of things, and improved the efficiency of data processing through artificial intelligence and cloud computing, while the blockchain accelerated the updating and dissemination of data. Sarma et al. [2] used the HDI method to construct a financial inclusion index. Based on the research results of the financial inclusion index system, Ambarkhane et al. [3] used digital support factor indicators to measure the development level of digital financial inclusion. Ge and Zhu [4] refer to the digital financial inclusion index system of Peking University to build a regional digital financial index. Their study showed that China's digital finance had a regional development situation with high levels in the eastern and low levels in the western regions. Conversely, the unbalanced development of the regional economy affected the development of digital finance. Zhang and Xing [5] used kernel density estimation and the Gini coefficient to explore the distribution dynamics and regional differences in the development of digital finance in the countryside of China.

Digital finance reduces information asymmetry and service costs. Lu [6] found that digital finance adopted digital technology to make up for the shortcomings of traditional financial services through scenarios, data, and financial innovation products. Kodan and Chhikara, Sharm, and Kim investigated how traditional financial development could effectively promote economic growth [7–9]. Noppasit [10] used a stochastic frontier model to simulate the production function, and showed that digital finance in Thailand positively promoted Thailand's economic growth. Cheng and Gong [11] concluded that improvement at the development level of digital inclusive finance could significantly promote the development of the real economy. Using the data of 31 provinces of China from 2011 to 2018, Qian et al. [12] found that digital finance had a positive impact on economic growth and that digital finance had a greater impact on economic growth in regions with low urbanization levels. The development of digital finance was conducive to improving the service quality of traditional financial institutions, promoting consumption upgrades, and driving economic growth. Zeng and Reinartz [13] addressed how digital finance changed the face-to-face transaction model in traditional financial services and facilitated the financial transaction process. Beck et al. [14] wrote that digital finance eased the liquidity constraints of residents by virtue of the convenience of mobile payment, and realized the intertemporal balance of consumption. Li et al. [15] pointed out that digital finance promoted online shopping, digital payment, purchase of internet financial products, online wealth management and commercial insurance, and other channels to promote household consumption. Sun et al. [16] used household survey data to conclude that the consumption level of Dalian residents was significantly affected by the development of digital finance, and the development of digital finance had a greater effect on the consumption promotion of residents of middle- and low-income families and residents with high education levels. In terms of promoting the income increase of rural residents and serving targeted poverty alleviation, Wen and Liu [17] used a panel regression model to analyze the income increase effect of the development of inclusive finance, and found that rural inclusive finance had a positive effect on the income of rural residents, and the effect was different with different incomes. In terms of promoting residents' entrepreneurship and enterprise innovation, Sarma and Pais [18,19] concluded that digital finance used digital technology to improve financial reform and solve financing problems. Beck et al. [20] constructed a general equilibrium model and concluded that mobile payment tools in digital finance promoted entrepreneurship, further driving economic growth. Zhang and Wen [21,22] addressed how resident entrepreneurship could be significantly affected by digital finance, but this effect varied with the object and between urban and rural areas. Li et al. [23] found that the development level of digital finance positively affected enterprise innovation input. It could be seen that the development of digital finance had a wide impact on residents, enterprises, and society.

There are also the following problems with the relationship between digital finance and economy: First, the analysis of the development characteristics of digital finance is still not in-depth, especially the study of the differences in the development of digital finance

between regions and within regions. Second, the relationship between finance and the real economy is one of the basic relationships that should always be handled thoroughly, and the research on the relationship between the development of digital finance and the growth of the real economy has not been deepened. Finally, there are regional imbalances in the development of digital finance and economic development in China. Do regional development differences affect the role of digital finance in the development of the real economy? And do the roles of digital finance in the development of the real economy remain the same at different levels of development of the real economy?

This paper will study the development characteristics of China's digital finance and the relationship between digital finance and the real economy. We use quartile images and kernel density estimation to analyze the distribution characteristics and dynamic evolution trends of China's digital finance, and build a regression model to explore whether digital finance can promote the growth of real economy. The main contributions of this paper are as follows: (1) Using quartile images to explore the spatial development pattern of digital finance in China, and identifying the differences of digital finance development between regions and within regions; (2) using the nonparametric method of kernel density estimation to analyze the dynamic distribution characteristics of overall and regional digital finance, and exploring the impact of regional development differences of digital finance on the real economy, which reveals the spatial differences in the development of the real economy; and (3) combining fixed-effect panel regression and quantile regression, we explore the impact of digital finance on the development of the real economy from different levels and perspectives, and deepen the research on the relationship between digital finance and the real economy.

The remainder of this paper is organized as follows: Section 2 presents the research methods and data analysis of this paper. Section 3 introduces the development characteristics and distribution dynamics of digital finance. Section 4 empirically analyzes the impact of digital finance on real economic growth. Finally, Section 5 summarizes the research and gives relevant suggestions.

2. Research Methods and Data Processing

2.1. Kernel Density Estimation

Kernel density estimation is an important nonparametric method with strong robustness and weak model dependence, which describes the real density function of random variables. The density function of random variable X is assumed as follows:

$$\hat{f}_n(x) = \frac{1}{nh_n} \sum_{i=1}^{n} K\left(\frac{X_i - x}{h_n}\right) \tag{1}$$

where n is the number of observation values, X_i is the independent and identically distributed observation value, x is a real variable, $K(\cdot)$ is the kernel function, and h_n is the band width. A smaller bandwidth is usually selected to ensure a higher estimation accuracy. As the choice of kernel function does not play a decisive role in the estimation, we select the Gaussian kernel function in this paper, which is as follows:

$$K(x) = \frac{1}{\sqrt{2\pi}} \exp\left(-\frac{x^2}{2}\right) \tag{2}$$

The curve of kernel density can describe the development characteristics of digital finance and the size of regional differences, and the development degree of digital finance can be obtained from the position of the curve. The extensibility of the curve is used to describe the regional difference between the provinces with high or low levels of digital financial development. The longer the curve drags, the greater the difference is. The number of curve peaks can reflect the degree of multi-polarization of digital finance development [5].

2.2. Panel Regression Models

In order to test the impact of digital finance development on the growth of real economy, this paper constructs the following regression model:

$$Y_{it} = \beta_0 + \beta_1 DIFI + \beta_2 X_{control} + u_i + \epsilon_{it} \quad (3)$$

where subscripts i and t represent provinces and years, respectively. Y is the dependent variable representing the level of real economy, $DIFI$ is the development degree of digital finance, and $X_{control}$ is the control variable. In addition, u_i represents the factor that does not change with time in each province and is used to control the regional fixed effect. ϵ_{it} is a random error term.

The effect of digital finance on promoting the growth of the real economy is not only affected by the differences in the development of digital finance, but also by the development degree of the real economy. Therefore, this paper uses quantile regression to analyze the impact of digital finance on the real economy at different levels of development. Quantile regression was first proposed by Koenker and Bassett in 1978. Compared with ordinary regression, it does not need to assume the distribution function of the error term, and it can also overcome the problem of heteroscedasticity. According to Equation (3), the quantile regression model is constructed as follows:

$$Q_Y(\tau|DIFI, X) = \beta_0(\tau) + \beta_1(\tau)DIFI + \beta_2(\tau)X_{control} + u_i + \epsilon_{it} \quad (4)$$

where τ is a real number satisfying $\tau \in (0,1)$.$Q_Y(\tau|DIFI, X)$ represents the τ quantile of Y under the condition of $DIFI$ and $X_{control}$. $\beta_0(\tau)$, $\beta_1(\tau)$, and $\beta_2(\tau)$ refer to the regression intercept and regression coefficient at the τ quantile. For the quantile regression model, it is necessary to optimize the empirical loss function (5) to obtain the corresponding parameter estimates:

$$min \sum_{t=1}^{T} \rho_x[Y_{it} - \beta_0(\tau) - \beta_1(\tau)DIFI - \beta_2(\tau)X_{control}] \quad (5)$$

where $\rho_x(\cdot)$ represents the loss function of quantile regression. By solving the minimization problem of Equation (5), the following equation can be obtained:

$$\hat{Q}_Y(\tau|DIFI, X) = \hat{\beta}_0(\tau) + \hat{\beta}_1(\tau)DIFI + \hat{\beta}_2(\tau)X_{control} \quad (6)$$

2.3. Indicators Selection and Data Analysis

This paper selects panel data of 31 provinces in the mainland of China from 2011 to 2020. The digital finance index is selected from the "Peking University Digital Inclusive Finance Index" compiled by the Peking University Research Center [24]. Data of the explained and control variables are selected from the National Bureau of Statistics of China and the National Statistical Yearbook.

The real economy is selected as the explained variable (Y). The core explanatory variable is digital finance index $(DIFI)$. The secondary indicators of digital finance are breadth of coverage (BC), depth of use (DU), and level of digitization (LD). Control variables are as follows: (1) Industrial structure (IS). The change of industrial structure will obviously change the development of the real economy. The industrial structure of the real economy is expressed as the ratio of added value of the secondary industry to the gross domestic product (GDP). (2) Financial scale (FS). The financing of the real economy sector is affected by the government's financial control, so the financial scale is expressed as the ratio of the fiscal expenditure of each province in the country to the GDP. (3) Foreign investment (FI). Foreign direct investment indirectly affects the financing of the production sector, thereby driving the development of the regional real economy. This paper uses the ratio of foreign direct investment to GDP to express the foreign investment ratio. (4) Urbanization level (UL). Densely populated cities develop rapidly in industrialization, so the impact of the urbanization level on the real economy cannot be ignored. The urbanization level is

expressed as the ratio of urban population to total regional population. (5) Labor input (LI). Economic development requires the input of the labor force, which is expressed by the proportion of employees in the total population of the region at the end of the year.

Logarithmic processing is used to unify the dimension on the data. Table 1 shows the descriptive statistics of each variable.

Table 1. Descriptive statistics of variables.

Variable	Sample Size	Mean	Std	Max	Min
Y	310	4.150	0.186	4.958	2.749
DIFI	310	2.265	0.086	2.635	1.210
BC	310	2.197	0.134	2.599	0.292
DU	310	2.256	0.080	2.689	0.830
LD	310	2.393	0.092	2.665	0.880
IS	310	1.600	0.010	1.792	1.203
FS	310	1.430	0.059	2.306	1.078
FI	310	1.446	0.142	3.497	0.681
UL	310	1.752	0.010	1.952	1.358
LI	310	1.760	0.002	1.896	1.635

In order to avoid multicollinearity in the following regression analysis, Pearson correlation coefficients are calculated in Table 2. It can be seen that the absolute values of the Pearson correlation coefficients among the variables are all less than 0.5, which indicates that the correlation between the core explanatory variable and the control variables is weak.

Table 2. Pearson correlation coefficient matrix.

Variable	*DIFI*	IS	FS	FI	UL	LI
DIFI	1.00					
IS	−0.40	1.00				
FS	−0.10	−0.21	1.00			
FI	0.16	−0.23	−0.04	1.00		
UL	0.48	−0.27	−0.32	0.17	1.00	
LI	−0.02	0.27	−0.01	−0.06	−0.30	1.00

3. Analysis on the Development Characteristics and Distribution Dynamics of Digital Finance

3.1. Research on the Development Characteristics of Digital Finance

According to the regional classification standards of the National Bureau of Statistics of China, we conduct a classification study on the development of digital finance in three major regions. First, the quartile image is used to investigate whether digital financial development can be classified by region.

As can be seen from Figure 1, the development level of China's digital finance cannot be completely divided by region, but there are obvious regional differences. The development level of China's digital finance gradually improves over time. In the past 10 years, the average value of China's digital financial index has increased from 40.59 to 341.22, which is developing very rapidly. In addition, the development of digital finance in China has regional differences and agglomeration. The development of digital finance in the eastern region of China is significantly better than that in the central and western regions, while the development of digital finance in the central region is significantly better than that in the western region. However, the development of digital finance in Hubei province, Sichuan province, and Chongqing is relatively good. This shows that the region will affect the development of digital finance, but it is not a decisive factor. The development space of digital finance in the central and western regions is relatively large.

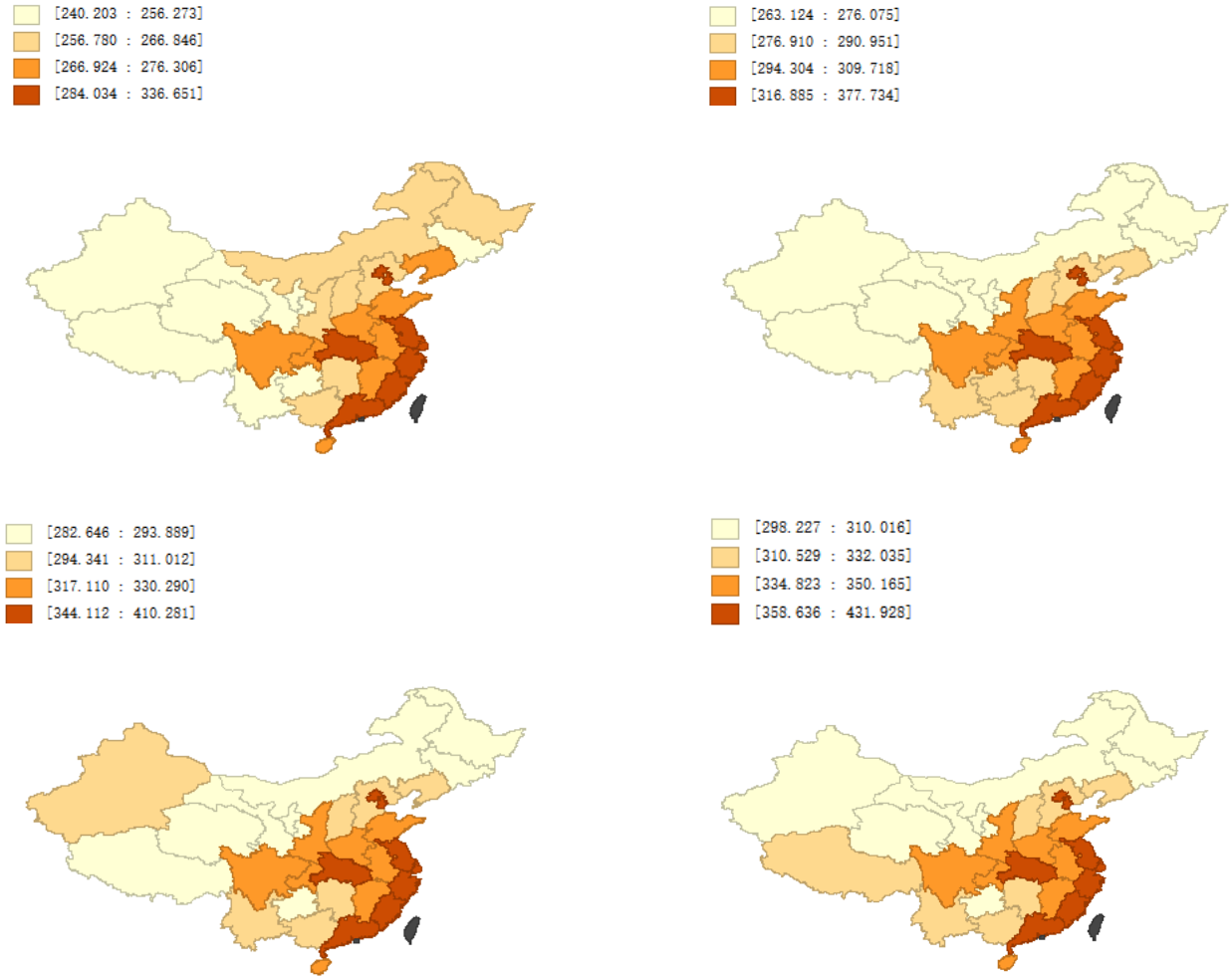

Figure 1. Quartile image of digital finance index from 2017 to 2020.

In a word, the development of digital finance in China has obvious regional differences, agglomeration, and other characteristics. When studying the development of digital finance, it can be classified by region.

3.2. Distribution Dynamics of Digital Finance Development

In order to explore the distribution and dynamic characteristics of digital finance development, this paper uses the method of kernel density estimation to analyze the characteristics of regional as well as the whole of China's digital finance development level, development differences, and polarization phenomena.

3.2.1. The Development and Distribution of Digital Finance

Figure 2a demonstrates that, first, during the entire sample observation period, the distribution location shows that the distribution of digital finance in 31 provinces across the country has gradually shifted to the right, which indicates that the development of digital finance in all regions has increased over time. Secondly, the distribution pattern indicates that the peak of the density curve is getting lower and lower, and the peak width shows a trend of not changing at first, followed by widening, which indicates that the gap in the development degree of digital finance is widening. Finally, the kernel density curve exhibits the "main peak" and "secondary peak", and the "secondary peak" disappears in 2020, which indicates that the development of digital finance has obvious polarization and uneven spatial distribution, but the polarization gradually disappears. However, the distribution ductility shows that there is a long tail on the right side of the density curve,

indicating that the development level of China's digital finance is mainly concentrated in the medium and low levels. In general, the development degree of digital finance continues to improve, but the development gap between provinces becomes larger, and there is regional imbalance. The economic development of China is uneven, and the level of digital finance infrastructure in different regions is different, which has led to obvious regional imbalance in the development of digital finance.

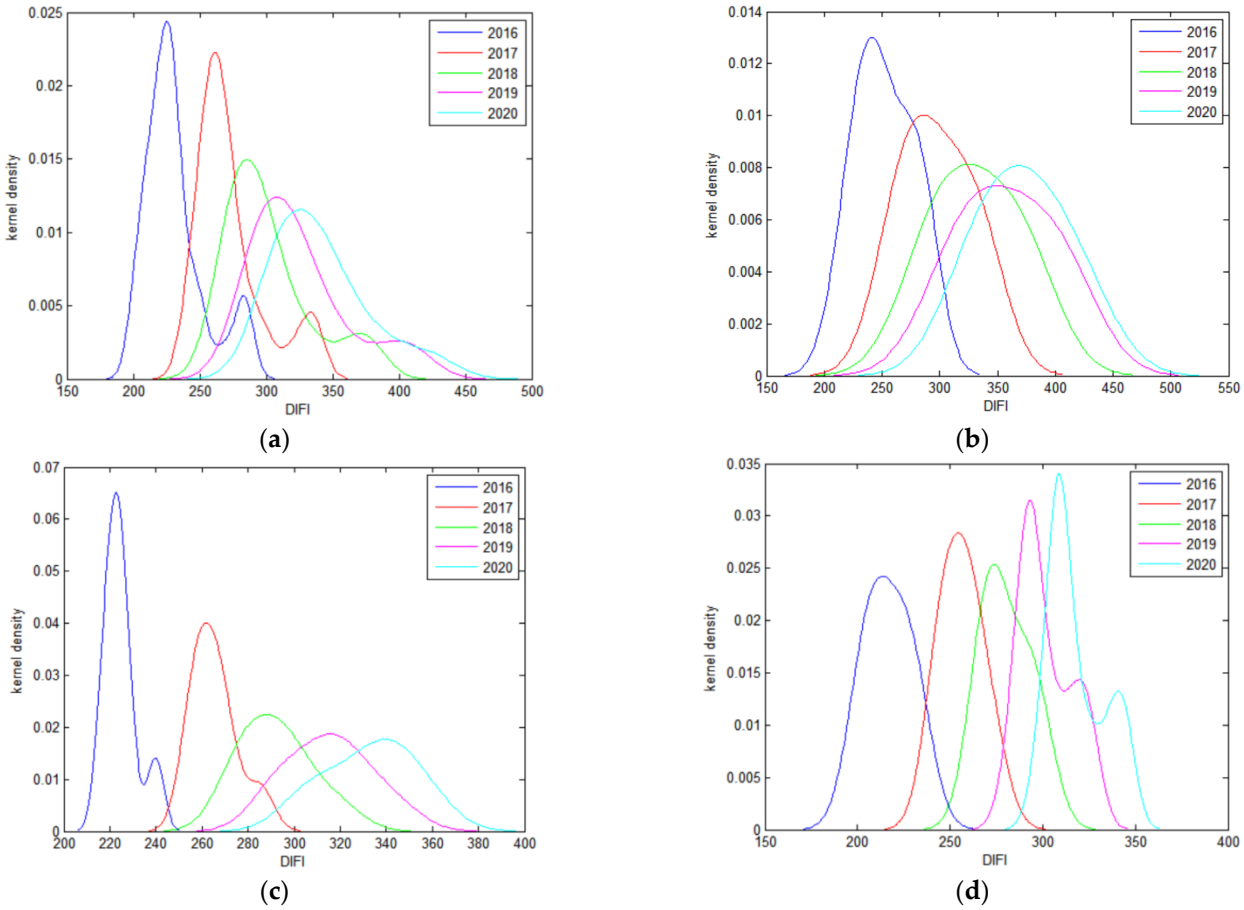

Figure 2. Distribution dynamics of digital financial development level. (**a**) The whole area; (**b**) the eastern region; (**c**) the central region; (**d**) the western region.

3.2.2. Digital Finance Development and Distribution Dynamics in Three Regions

Figure 2b shows that, first, the development of digital finance in the eastern region has shifted to the right, which indicates that the digital finance development level of the eastern provinces has improved. Secondly, the peak height of the kernel density curve first decreased and then increased, and the peak width experienced a change of obvious widening and then a small reduction, which means that the gap in the development level of digital finance in the eastern region first widens and then slightly narrows. In addition, there has been a tailing phenomenon on the right side of the kernel density curve in the eastern region in the past two years, which shows that the development of digital finance in the eastern region is concentrated at the medium and above levels, with a small number of provinces with excellent development, and there is no multi-level differentiation phenomenon.

From Figure 2c, we conclude that, first, the development of digital finance in the central region has also shifted to the right, which indicates that the development of digital finance in the central region is also gradually improving. Secondly, the peak height of the kernel density curve first dropped sharply and then decreased slightly, and the peak width first widened slightly and then widened significantly, which indicates that the gap in the

development level of digital finance in the central region has increased significantly in recent years. Finally, the double peaks of the kernel density curve in the central region gradually disappeared, but there was obvious tailing on the left and right sides, which means that although the polarized distribution of digital finance development in the central region disappeared, the gap within the region did not decrease.

From Figure 2d, we obtain that, first, the development of digital finance in the western region also shifted to the right, which indicates that the development of digital finance in the western region is also gradually improving. Secondly, the peak height of the kernel density curve shows a change of rising, falling, and rising, and the width of the peak narrows, widens, and narrows, and the change in width is relatively insignificant, which means that the overall gap in the development level of digital finance in the western region has narrowed. In addition, the two sides of the kernel density curve showed an obvious convergence trend, and the tailing phenomenon weakened, and a "secondary peak" appeared on the right side in the past two years. This shows that the development level of digital finance in the western region is relatively low, and the regional gap is small, but polarization has appeared in the past two years.

In general, the development level of digital finance in the three regions has gradually improved, but the improvement rate in each region is different. Among them, the development speed of the eastern region is the fastest. The central region has the largest gap, and the western region has relatively balanced development, but the development speed is slow and the development space is large. Moreover, the regional development differences of digital finance may cause spatial differences in the impact on the real economy.

4. Analysis of the Effect of Digital Finance on the Real Economy

4.1. Panel Regression Analysis of Digital Finance on the Real Economy

4.1.1. The Development of Digital Finance and the Growth of the Real Economy

First, we construct static panel regression and dynamic panel regression models. In the static panel regression model, the fixed-effect model is selected, and the GMM system estimation method is used in the dynamic panel regression model. The regression results are shown in Table 3. Column (I) is the dynamic panel regression model, and Column (II) is the estimated result of the fixed effect regression model. In the dynamic panel regression model, the impact of digital finance on the real economy is not significant, and the model fails the test, but the regression effect is good and significant in the fixed effect model. Therefore, this paper uses a fixed effect model to analyze the relationship between digital finance and the real economy, and applies the robust standard error method to solve the heteroscedasticity problem.

In the aspect of control variables, foreign investment and urbanization level significantly promote the growth of the real economy. This paper uses the proportion of foreign direct investment to represent foreign investment. Foreign investment promotes the development of domestic enterprises, which in turn promotes the growth of the domestic real economy. Areas with a high level of urbanization have a large number of laborers, which promotes the rapid development of urban industrialization. Therefore, the level of urbanization significantly promotes the growth of the regional real economy. Overall, the impact of foreign investment and urbanization level variables on the real economy is in line with expectations. The industrial structure is expressed as the proportion of the added value of the secondary industry, which does not have a significant promoting effect on the real economy. It may be that the "virtual economy" has developed rapidly in recent years, which leads to an insignificant impact of the industrial structure on the real economy. Financial scale has a negative impact on the growth of the real economy. A possible explanation is that local fiscal expenditures are often used to strengthen infrastructure construction in regions, thus accelerating the economic growth of the real estate industry. The service to the real economy is not perfect, and the incentive effect is not enough, so the impact on the real economy is negative. With the rapid development of industrial automation, the mechanization of factories has increased, and the required labor force has decreased, so the impact of labor input on the real economy is not significant.

Table 3. Panel regression results of primary indicators and secondary indicators.

Variable	(I) GMM	(II) Fixed-Effect	(III) BC	(IV) DU	(V) LD
Y_{t-1}	0.776 ***				
	(0.021)				
$DIFI$	−0.002	0.124 ***			
	(0.007)	(0.015)			
CB			0.073 ***		
			(0.015)		
UD				0.111 ***	
				(0.022)	
DL					0.097 ***
					(0.016)
IS	−0.242 ***	−0.206	−0.337	−0.252	−0.179
	(0.026)	(0.233)	(0.242)	(0.222)	(0.216)
FS	−0.221 ***	−0.308 *	−0.291	−0.286	−0.328 *
	(0.04)	(0.148)	(0.144)	(0.143)	(0.155)
FI	0.084 ***	0.061 *	0.054 *	0.049 *	0.068 **
	(0.007)	(0.024)	(0.025)	(0.023)	(0.023)
UL	0.061	1.412 ***	1.557 ***	1.574 ***	1.688 ***
	(0.051)	(0.223)	(0.243)	(0.206)	(0.171)
LI	0.456 ***	0.187	0.248	0.248	0.174
	(0.048)	(0.178)	(0.19)	(0.186)	(0.173)
Constant		1.746 **	1.697 *	1.445 *	1.31 *
		(0.608)	(0.68)	(0.605)	(0.567)
The fixed effect		Yes	Yes	Yes	Yes
AR(2)	0.053				
Sargan test	0.305				
R^2		0.864	0.852	0.858	0.872

Note: ***, ** and * represent significant levels at 1%, 5% and 10%, respectively, the standard errors obtained by regression are in parentheses.

4.1.2. Secondary Indicators of Digital Finance and the Growth of the Real Economy

The secondary indicators of the digital financial index include the breadth of coverage, depth of use, and level of digitization. Therefore, we will further analyze how the secondary indicators of the digital financial index affect the development of the real economy from the structure. The results are shown in columns (III), (IV), and (V) in Table 3. The results show that the three secondary indicators of digital finance all have a positive impact on the growth of the real economy, which further verifies digital finance's significant promotion of the growth of the real economy. Among the indicators, the digital financial depth of use index has the greatest impact on the real economy. The digital financial depth of use index is reflected by the actual use of digital financial services. The digital financial breadth of coverage is represented by the number of electronic accounts, which is different from the number of traditional financial institutions and financial service personnel in the past. It guides the flow of funds to the real economy, thereby driving the growth of the real economy. The level of digitization reflects the low-cost and low-threshold advantages of digital financial services, and promotes economic development [22].

4.1.3. Regional Digital Finance Development and Real Economic Growth

Since the 20th century, China's economic development has shown a regional imbalance. Therefore, we empirically analyze whether the effect of digital finance on the growth of the real economy is the same in different regions. The results are shown in Table 4. Overall, the development of digital finance in all regions can still significantly and positively promote the growth of the real economy, which shows that the panel regression results in this paper are relatively stable. Among them, digital finance in the more developed eastern region has the greatest impact on the growth of the real economy, followed by the central and western regions. It is concluded that in areas with rapid economic development, digital finance has

a stronger role in promoting the real economy and can better drive the growth of the real economy [25].

Table 4. Regional panel regression results.

Variable	(I) Eastern Region	(II) Central Region	(III) Western Region
DIFI	0.113 **	0.069 **	0.089 ***
	(0.035)	(0.02)	(0.016)
IS	−0.804 *	0.235	0.134
	(0.319)	(0.137)	(0.251)
FS	−0.142	−0.535 ***	−0.225
	(0.268)	(0.06)	(0.192)
FI	0.03	0.056	0.048
	(0.033)	(0.037)	(0.025)
UL	1.383 *	2.169 ***	1.799 ***
	(0.598)	(0.216)	(0.243)
LI	0.322	−0.06	−0.192
	(0.194)	(0.096)	(0.137)
Constant	2.395	0.586	1.067
	(1.646)	(0.404)	(0.867)
The fixed effect	Yes	Yes	Yes
R^2	0.86	0.962	0.956

Note: ***, ** and * represent significant levels at 1%, 5% and 10%, respectively.

4.2. Quantile Regression Analysis of Digital Finance and Real Economic Growth

Differences in the development of the real economy will also affect the impact of digital finance on it. Therefore, this paper further considers the quantile regression model, and conducts regression for different quantiles of real economic development to explore the impact of digital finance on different real economic quantiles.

Table 5 shows that digital finance plays a positive role in promoting the development of the real economy. However, with the change of quantiles, there are certain differences in the impact on different real economic development levels. The promotion of digital finance to the real economy generally shows a downward trend. The higher the development level of the real economy, the smaller the promotion effect of digital finance on it. The reason may be that digital finance and the real economy have not achieved the same development, with the real economy developing rapidly. Therefore, finance and the real economy should keep pace with the development of the real economy. Financial development that is too fast or too slow will hinder the development of the real economy [11].

Table 5. Quantile regression results of China.

	τ = 0.1	τ = 0.25	τ = 0.5	τ = 0.75	τ = 0.9
DIFI	0.621 ***	0.5 ***	0.34 ***	0.355 ***	0.322 ***
	(0.119)	(0.05)	(0.053)	(0.046)	(0.012)
Control variables	Yes	Yes	Yes	Yes	Yes
Individual fixation effect	Yes	Yes	Yes	Yes	Yes
Time fixed effect	Yes	Yes	Yes	Yes	Yes
Observations	310	310	310	310	310

Note: *** represent significant level at 1%.

Tables 6–8 show that the development of digital finance in three major regions can positively promote the growth of the real economy. However, there are certain differences in the impact on the development of different real economies at different quantiles. Specifically, with the quantile varying from 0.1 to 0.9, the promotion effect of digital finance on the real economy in the eastern region shows a trend of rising first and then decreasing, which indicates that digital finance in the eastern region has the greatest effect on the development

level of the medium real economy. It may be that the eastern region is economically developed and digital finance is relatively advanced, and industrial upgrading is in a critical period. Digital finance is consistent with the development level of the medium real economy, so the promotion effect is greatest at this time. Compared with the central and western regions, digital finance in the eastern region has the greatest impact on the real economy. The promotion of digital finance to the real economy in the central region generally shows a downward trend. However, the impact of digital finance has not changed significantly under the development of different real economies in the western region. It may be that the economic and digital finance development are relatively slow. It is possible to increase the level of digital financial development by increasing the construction of digital financial infrastructure, which may promote the growth of the real economy.

Table 6. Quantile regression results of eastern region.

	τ = 0.1	τ = 0.25	τ = 0.5	τ = 0.75	τ = 0.9
DIFI	0.494 * (0.211)	0.756 *** (0.068)	0.632 *** (0.103)	0.524 *** (0.111)	0.504 *** (0.088)
Control variables	Yes	Yes	Yes	Yes	Yes
Individual fixation effect	Yes	Yes	Yes	Yes	Yes
Time fixed effect	Yes	Yes	Yes	Yes	Yes
Observations	110	110	110	110	110

Note: *** and * represent significant levels at 1% and 10%, respectively.

Table 7. Quantile regression results of central region.

	τ = 0.1	τ = 0.25	τ = 0.5	τ = 0.75	τ = 0.9
DIFI	0.5 *** (0.09)	0.385 *** (0.063)	0.327 *** (0.044)	0.38 *** (0.055)	0.287 *** (0.049)
Control variables	Yes	Yes	Yes	Yes	Yes
Individual fixation effect	Yes	Yes	Yes	Yes	Yes
Time fixed effect	Yes	Yes	Yes	Yes	Yes
Observations	80	80	80	80	80

Note: *** represent significant level at 1%.

Table 8. Quantile regression results of western region.

	τ = 0.1	τ = 0.25	τ = 0.5	τ = 0.75	τ = 0.9
DIFI	0.226 (0.153)	0.151 (0.166)	0.203 * (0.081)	0.154 (0.08)	0.174 * (0.087)
Control variables	Yes	Yes	Yes	Yes	Yes
Individual fixation effect	Yes	Yes	Yes	Yes	Yes
Time fixed effect	Yes	Yes	Yes	Yes	Yes
Observations	120	120	120	120	120

Note: * represent significant level at 10%.

4.3. Model Test

In order to ensure the reliability of the results, this paper performs the following tests:

4.3.1. Residual Normality Test

In order to prove the validity of the panel regression results, the residual normality test is considered. It can be seen from Figure 3 that the *p*-values of the J-B statistic are all greater than the significance level (0.05), and the null hypothesis cannot be rejected. This means that the residuals of the fixed-effect panel regression model pass the normality test.

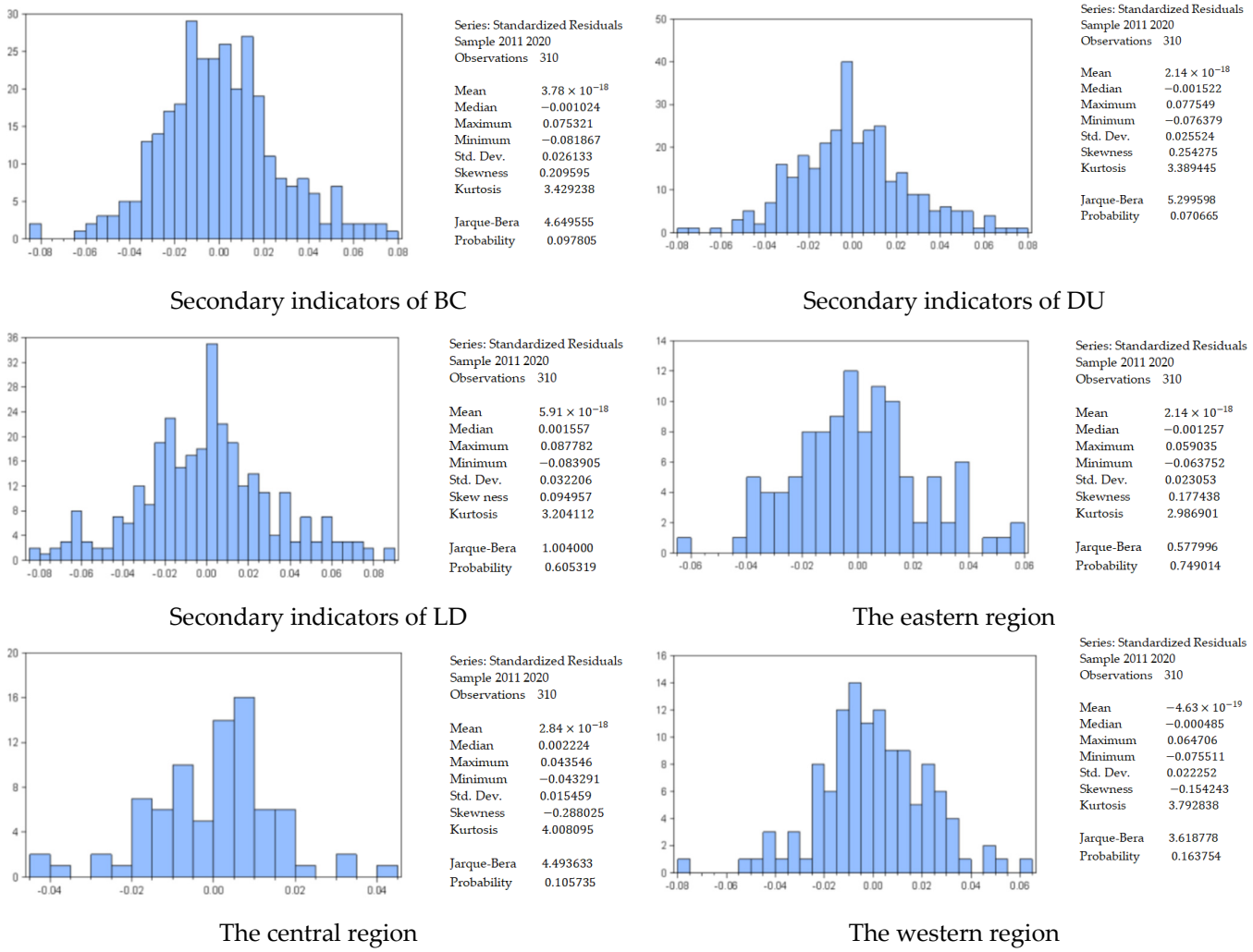

Figure 3. Residuals normal test.

4.3.2. Robustness Test

1. This paper takes the digital financial index as the core explanatory variable. The regression results are shown in column (I) in Table 9. The results show that digital finance still significantly promotes the growth of the real economy, and the parameter estimates and significance of explanatory variables have not changed significantly, indicating that the estimation results of this paper are robust.

Table 9. Robustness test.

	(I) Substitution Variables	**(II) Excluded Area Sample**
DIFI	0.092 ***	0.117 ***
	(0.008)	(0.021)
Control variables	Yes	Yes
Individual fixation effect	Yes	Yes
Time fixed effect	Yes	Yes
Observations	310	270
R^2	0.956	0.89

Note: *** represent significant level at 1%.

2. There are obvious regional differences in China's economic development, which may act as an exogenous factor to affect the promotion of digital finance to the real

economy. Therefore, this paper removes the top and bottom four provinces of the real economy in the past ten years—Guangdong, Jiangsu, Qinghai and Tibet—and returns the remaining panel data. The results are shown in column (II) in Table 9. It can be seen that after excluding samples from some regions, the parameter estimation and significance of the explanatory variables do not change significantly, which indicates that the estimated results in this paper are robust.

Combining the above two robustness tests, it can be seen that neither parameter estimation nor significance has changed significantly, which effectively verifies the results of this study as robust and reliable.

5. Conclusions and Suggestions

This paper analyzes the development status and distribution characteristics of digital finance in China, and explores the role of digital finance in promoting the growth of the real economy. The following conclusions are obtained:

First, the development of digital finance in China is uneven, and the distribution characteristics of digital finance in different regions are different. From the quartile images and kernel density curves, it is found that there are obvious regional differences and agglomeration in the development of digital finance in China. The development of digital finance in the eastern region is generally better than that in the central and western regions, and the central region is better than the western region. There are also different degrees of differences in the development of digital finance in the region. The development of digital finance in the eastern provinces is concentrated at the medium level and above, with high spatial agglomeration and no multi-level differentiation. The uneven development in the central region is the most serious. Regions with a high level of development are developing faster than those with a low level, resulting in a growing disparity within the region. The development of digital finance in the western region is relatively concentrated, and the development differences within the region are small, but polarization has appeared in the past two years.

Secondly, digital finance in China has clearly promoted the development of the real economy. According to the fixed effect model, it follows that digital finance significantly promotes the growth of the real economy. The secondary indicators of digital finance play a role in promoting the growth of the real economy, of which the depth of use index has the greatest impact on the real economy. A quantile regression model is further constructed to consider whether the role of digital finance on it changes under different levels of development of the real economy. This study shows that in different quantiles of the real economy, digital finance can still significantly promote the growth of the real economy, but the impact shows fluctuating changes.

Thirdly, digital finance has significantly promoted the growth of the real economy in different regions of China, and the degree of promotion is different. The fixed effect and quantile models show that the development of digital finance in the eastern region has the greatest promotion effect on the real economy, which indicates that the promotion effect of digital finance on the real economy is most obvious in areas with rapid economic development. This is because digital finance in the eastern region has developed rapidly and achieved consistent development with the real economy. However, the development of digital finance in the central and western regions is slow, and the impact on the development of the real economy is relatively significant.

Based on the above conclusions, the following suggestions are given:

(1) Promoting the simultaneous development of digital financial regions. The development of digital finance in China is uneven, and the status quo of the digital divide still needs to be resolved. Appropriate policy approaches should be developed according to regional characteristics. For the relatively underdeveloped regions, the government should focus on accelerating the construction of digital finance, improving financial resources, increasing the ownership rate of digital products, and supporting digital industries and digital talents so that both urban and rural areas can enjoy the financial

services of digitalization. For the well-developed regions, the level of scientific and technological innovation should be further strengthened, digital information technology should be improved, digital finance should be developed in a healthy manner, and the efficiency of financial transaction services should be improved.

(2) Improving the efficiency of digital finance in promoting the development of the real economy. Digital finance has promoted the growth of China's real economy. It is necessary to continue to promote the healthy development of digital finance, improve the efficiency of promoting the growth of the real economy, and accelerate the flow of funds to the real economy. The government should coordinate the overall situation, formulate appropriate development strategies, and avoid the development of digital finance without a purpose. It must respect the laws of market development, ensure the simultaneous development of digital finance and the real economy, and promote the growth of the real economy with high efficiency. In addition, we can optimize the development of digital finance in many aspects, especially by strengthening the construction of digital finance, supporting the development of the real economy in a more comprehensive and convenient way, and guiding the development of the economy "from virtual to real".

(3) Advancing measures for the priority development of digital finance and improving the financial supervision system. The digital attributes and inclusiveness of digital finance have improved traditional finance, and the development of digital finance should be given priority. Digital finance is not limited by time and space, and is aimed at a wider group, which also creates new potential risks. Therefore, it is necessary to improve the financial supervision system, clarify the industry access threshold, and strictly control the financial credit system. Furthermore, the avoidance of potential risks in the field of digital finance should be strengthened, strict laws and regulations should be established, and the rights and interests of financial consumers in accordance with the law must be protected.

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