Research on the Impact of Digital Finance on the Development of the Real Economy

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Abstract: Based on the inclusiveness, financial attributes and technological nature of digital finance, this study probes into the impact mechanism on the total factor productivity (TFP) of the real economy, analyzes the regional differences of digital finance and the intermediary effect of technological innovation. Research has shown that digital finance can improve the TFP prominently. In the mechanism test, the financial nature has the most remarkable impact on TFP, with a U-shaped relationship between technology and the real economy, and there is an "information cocoon". In heterogeneity analysis, the TFP in central region is most notably affected by digital finance, while the degree of inclusivity is lacking in the western region. Technological innovation is an important transmission variable.

Keywords: Digital finance; The real economy; TFP; Fixed effects

1 Introduction

With the improvement of blockchain, cloud computing and other technologies in China, a new level of financial inclusivity has emerged [1]. Subsequently, digital finance emerged under the integration of finance and technology. At the macro level, Beck et al. initially believed that inclusive finance could create incentive effects and accelerate economic growth from the perspective of financial service accessibility [2]. At the micro level, digital finance expands corporate financing channels [3], improves regional innovation levels [4], and promotes the improvement of TFP of enterprises [5]. Also, digital finance reduces the level of enterprise financialization [6], avoids excessive detachment from the real economy, and indirectly improve the TFP of enterprises. Wang R. et al. consider that digital finance can facilitate financial availability and resource allocation efficiency, advance the development of high-quality economy [7]. Hou et al. used the digital inclusive finance index as a proxy variable for fintech, believing that fintech promotes the improvement of TFP through innovation capabilities and technology spillover effects [8]. Digital inclusive finance can stimulate the efficiency improvement of financial services to the real economy through reshaping of financial elements and innovation [9].

The above research literature mainly includes studies on digital finance and macroeconomic growth, as well as TFP of micro enterprises. This article is mainly reflected in: firstly, exploring how digital finance can leverage its advantages, expanding literature research on TFP of the real economy from the perspective of its characteristics. Secondly, test how

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inclusiveness, financial attributes and technological of digital finance influence the TFP of the real economy, analyze the routes in which digital finance promoting the real economy.

2 Mechanism analysis

2.1 The inclusiveness of digital finance on TFP

Traditional financial institutions and internet companies utilize digital technology to achieve new financial business models, which called digital finance [10]. Gomber et al. proposed the "Digital Finance Cube", believed that digital finance includes digital financing, digital investment, digital currency, digital payment, digital insurance, and digital financial advice [11], which has the characteristics of inclusiveness, financial attributes, and technological. The mechanism analysis is shown in Figure 1.

Digital finance improves the TFP of the real economy by covering the long tail group from the perspective of "incremental supplementation". It advances financial inclusiveness in emerging and developed economies [12], filling the service gaps of traditional financial institutions [13], and expanding the coverage of digital finance services. Digital finance, with its advantages of wide coverage, fast speed and low cost, meets the financing needs of the typical niche market, enhances the financing scale of the real economy, and directly improves TFP.

Hypothesis 1: The high degree of inclusiveness of digital finance can improve the TFP.

2.2 The financial attributes of digital finance on TFP

The financial and technological aspects of digital finance complement each other, promoting the improvement of TFP of the real economy from the perspective of "Inventory optimization". Digital finance enhances the function of financial intermediaries as information exchange media. For the current situation in China where banks are the main financing channels, the digital finance strengthens cooperation between technology companies and traditional financial institutions, reduces information asymmetry and credit mismatch. At the same time, digital financing, digital investment, gather a large amount of idle funds in the market and efficiently allocate them, alleviating the liquidity mismatch of the real economy. For example, Yu'ebao, gathers a large amount of idle funds to meet the liquidity needs of many customers.

Hypothesis 2: The deepening financial function of digital finance will enhance the TFP.

2.3 The technological of digital finance on TFP

Digital finance accelerates the integration of finance and digital technology, alleviates the imbalance in regional development of the real economy, and directly improves TFP. The spatial penetration of digital technology can not only guide capital flow across regions, but also promote local TFP and generate spatial spillovers. However, due to the shortage of digital financial talents, regional institutional environment differences, "information cocoons" and "digital divide", regional differences have expanded. Therefore, the technological of digital finance may have negative effects on the TFP. In the stage of further integration of technology and finance, facilities of digital finance are improved, elements flow smoothly across regions, regional development is balanced.

Hypothesis 3: the technological of digital finance has a non-linear U-shaped impact on the TFP.

Digital finance stimulates financial competition, promotes technological innovation, and indirectly promotes the improvement of TFP in the real economy. Digital finance has the "catfish effect" [14], with its huge advantages of low marginal costs and efficient resource allocation, forcing traditional financial institutions with weak competitiveness to exit the market or undergo digital transformation. The competition in the financial industry further forces various physical departments to participate in market competition, adhere to technological innovation, enhance their competitiveness, and obtain enough fund. The increase in innovation activities in the physical industry will improve the technological level of the whole society and promote the improvement of TFP in the long run.

Hypothesis 4: Digital finance will enhance the TFP through technological innovation.

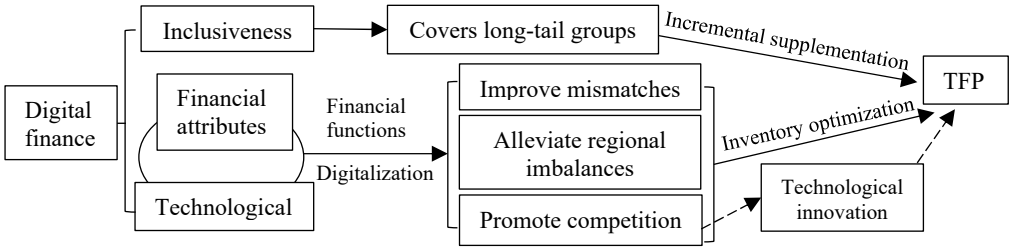

Fig.1. Mechanism analysis of digital finance on TFP

3 Model and variable description

3.1 Econometric model

a. Benchmark model. Based on the above theoretical analysis, to test whether digital finance has an impact on TFP of the real economy, we establishes the following regression equation (1):

$$TFP_{it} = \beta_0 + \beta_1 Dif_{it} (Width + Depth + Digital + Digital^2) + \beta_2 Control_{it} + \lambda_i + \varepsilon_{it} \quad (1)$$

Among them, TFP_{it} stands for the total factor productivity of the real economy in year t in region i; Dif represents the level of digital finance development, represented by the Width, the Depth, and the Digital, respectively, with the addition of the quadratic term $Digital^2$; λ represents regional fixed effects; ε represents a random perturbation term.

b. Mediation effect model. This article uses technological innovation as a mediating variable to validate the mediating effect of technological innovation. Therefore, based on model (1), the following mediation effect model is established using the three-part regression method:

$$TFP_{it} = \beta_0 + \beta_1 Dif_{it} + \beta_2 Control_{it} + \lambda_i + \varepsilon_{it} \quad (2)$$

$$Inno_{it} = \gamma_0 + \gamma_1 Dif_{it} + \gamma_2 Control_{it} + \lambda_i + \varepsilon_{it} \quad (3)$$

$$TFP_{it} = \alpha_0 + \alpha_1 Dif_{it} + \alpha_2 Inno_{it} + \alpha_3 Control_{it} + \lambda_i + \varepsilon_{it} \quad (4)$$

In the above equation, Inno represents the level of technological innovation. Firstly, regress equation (2), if the β_1 coefficient is significant, regress equations (3) and (4) separately to test whether the coefficients γ_1 and α_2 are significant. If both coefficients are significant, there is a mediating effect. If α_1 is not significant, there exist a complete mediating effect, and vice versa, a partial mediating effect.

3.2 Variable description

Based on the availability of data, this study selects 30 provinces in China except Tibet from 2011 to 2020 as the analysis samples, and uses the Winsorize method to shrink the tail of each proxy variable, the descriptions are shown in Table 1. For the calculation of TFP, using the GDP of each province after deducting the financial and real estate industries as output [15], using labor and capital as inputs. The labor is the number of employees that deduct employment in the financial and real estate industries. According to Zhang Jun et al. [16], we use the perpetual inventory method to calculate the capital, the formula is: Kit=Kit-1(1-δit) +Iit / Pit。Where I represents the fixed assets investment, δ is the depreciation rate that takes 10.96%, P is the price index of fixed assets investment.

Table 1. Description of various variables[1]

	Variables	Description	Count	Mean
Explained Variable	Total factor productivity of the real economy (TFP)	Using the DEA Malmquist index to calculate the TFP	300	1.026
Explanatory variables	Level of digital finance (Dif)	The digital inclusive finance index compiled by the Digital Finance Research Center of Peking University	300	5.219
	Coverage of digital finance (Width)		300	5.075
	The depth of use of digital finance (Depth)		300	5.201
	The degree of digitization (Digital)		300	5.510
Control variables	Fixed capital investment (Cap)	Ratio of fixed capital investment to GDP	300	0.834
	Economic openness level (Open)	Ratio of regional import and export trade volume to GDP	300	1.139
	Human capital level (HC)	Per capita actual human capital level of provinces using the J-F method	300	5.859
	Institutional quality (Ins)	The Provincial Marketization Indexs	300	7.893
	Industrial structure (Str)	Ratio of added value of the tertiary industry to regional GDP	300	0.489
	Infrastructure level (Infr)	Per capita highway mileage in the province	300	3.475
Mediating variable	Technological innovation (Inno)	Number of invention patent applications	300	9.178

[1] The data are sourced from *the Digital Inclusive Finance Index*, *the China Statistical Yearbook*, *the China Provincial Marketization Index*.

4 Empirical analysis

4.1 Benchmark regression

As shown in Table 2, the digital finance can improve the TFP in real economy, which is significant at the 1% level. From columns 2 and 6, the Width has a positive effect on the TFP at a significance level of 1%, indicating that digital finance has broken through the limitations of traditional physical outlets, covered the long tail group, and improved the degree of financial inclusiveness, hypothesis 1 is valid. The Depth in columns 3 and 7 is significantly positive, indicating that with the support of digital technology, financial functions have been largely realized, hypothesis 2 is valid. Columns 4 and 8 show the Digital has negative effect on the TFP, the $Digital^2$ is significantly positive, indicating a non-linear U-shaped relationship between technological and TFP. China's digital finance technological and the real economy are in a period of development obstruction, which verifies hypothesis 3.

Table 2. Estimated results of the real economy and digital finance

Variables	TFP							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dif_{t-1}	0.086***				0.118***			
	(5.16)				(4.67)			
$Width_{t-1}$		0.046***				0.044***		
		(3.65)				(2.67)		
$Depth_{t-1}$			0.097***				0.116***	
			(5.90)				(4.82)	
$Digital_{t-1}$				-0.057***				-0.059***
				(-4.00)				(-4.54)
$Digital^2_{t-1}$				0.001				0.005***
				(0.67)				(2.90)
Fixed effects	N	N	N	N	Y	Y	Y	Y
Count	270	270	270	240	270	270	270	240
adj R^2	0.308	0.274	0.327	0.235	0.304	0.261	0.308	0.261

4.2 Regional regression

Due to differences in policies, digital finance development levels, and talent capital among regions et al. in China, we further divides sample data from 30 provinces across the country into eastern, central, and western regions. The differences among each region are shown in Table 3.

Table 3. Fixed effect model estimation results for three major regions

Variables	Digital finance			Width		
	eastern	central	western	eastern	central	western
Dif_{t-1}	0.143*	0.285***	0.111***			
	(1.92)	(4.41)	(3.12)			
$Width_{t-1}$				0.122*	0.129**	0.034
				(1.97)	(2.41)	(1.58)

Count	99	72	99	90	72	99
adj_R^2	0.235	0.436	0.314	0.237	0.314	0.255
Variables	Depth			Digital		
	eastern	central	western	eastern	central	western
$Depth_{t-1}$	0.023	0.231***	0.142***			
	(0.41)	(4.70)	(3.95)			
$Digital_{t-1}$				-0.071***	-0.075**	-0.043**
				(-3.71)	(-2.18)	(-2.16)
$Digital^2_{t-1}$				0.007**	0.003	0.006**
				(2.54)	(0.62)	(2.12)
Count	99	72	99	88	64	88
adj_R^2	0.202	0.455	0.356	0.274	0.266	0.297

According to Table 3, digital finance has an outstanding advancing effect on the TFP in each region. Among them, the Width is not markable in the western region, which means the degree of inclusiveness is insufficient. The Depth is positive in the central and western regions notably, but not in the eastern regions. Considering that the $Digital^2$ degree in the eastern region is significantly positive, this may be due to the emergence of "information cocoons". The more developed digital finance technology is in the eastern provinces and cities, the more capital outflow is restricted, which hinders the full play of financial functions in the eastern region. The Digital is negative at least 5% in every region, and the quadratic coefficients are all significantly positive except for the middle, indicating that the technological nature in all regions is in the stage of inhibiting the TFP, and there is still room for further integration of digital technology and financial services in all regions.

4.3 Robustness testing

a. Change the measurement method. To address the endogeneity issue of fixed effects models, the GMM model is used to test the empirical results. From Table 4, the results of GMM model are reasonable and effective. From columns 1 and 6, the overall digital finance development level is markable positive on the TFP at the 1% level. The 2-5 columns respectively tested how the Width, Depth, and Digital affect the TFP, the results are roughly the same as the empirical results mentioned earlier.

Table 4. Estimated results of replacing measurement methods

Variables	System-GMM					Twostep-GMM
	(1)	(2)	(3)	(4)	(5)	(6)
TFP_{t-1}	0.303***	0.376***	0.391***	0.489***	0.388***	0.305***
	(3.26)	(3.73)	(4.81)	(4.98)	(4.72)	(2.61)
Dif_{t-1}	0.056***					0.056**
	(2.79)					(2.07)
$Width_{t-1}$		0.033				
		(1.62)				
$Depth_{t-1}$			0.050***			
			(3.05)			
$Digital_{t-1}$				-0.026	-0.029*	
				(-1.69)	(-1.97)	
$Digital^2_{t-1}$					0.001	
					(1.22)	
Count	270	270	270	240	240	270

AR(1)	0.014	0.011	0.007	0.002	0.001	0.037
AR(2)	0.127	0.257	0.347	0.383	0.173	0.105
Hansen	0.234	0.261	0.305	0.289	0.777	0.234

b. Exclude special provinces. Due to the superior economic development advantages of municipalities, the digital finance may be overestimated. Therefore, excluding the four municipalities of Beijing, Tianjin, Shanghai, and Chongqing, the results using a fixed effects model are shown in Table 5. Digital finance still positive on the TFP of the real economy and is markable at the level of 1%, the basic conclusions are generally the same.

Table 5. Estimated results excluding municipalities

Variables	Fixed-effect			
	(1)	(2)	(3)	(4)
Dif_{t-1}	0.135***			
	(5.20)			
$Width_{t-1}$		0.048***		
		(2.82)		
	(1)	(2)	(3)	(4)
$Depth_{t-1}$			0.129***	
			(5.21)	
$Digital_{t-1}$				-0.065***
				(-4.47)
$Digital^2_{t-1}$				0.006***
				(3.00)
Count	234	234	234	208
adj_R^2	0.352	0.293	0.353	0.278

4.4 Mediation effect analysis

The mediating effect conclusions are shown in Table 6. From 2 column, the digital finance has an insignificant positive effect on Inno. After adding the intermediary variable Inno, the coefficient of influence decreases, but still notable at level 1%. Technological innovation also positive and significant on TFP. Due to the presence of a coefficient that is not significant, the Sobel test is used to determine whether the mediating effect is outstanding. As Table 7 shows, the Z-value is 1.825, the P-value is 0.068, indicating that at least at a 10% significance level, the mediating effect is established, which accounts for 24.3% of the total effect, technological innovation plays a mediating role, hypothesis 4 holds.

Table 6. Intermediary effects of technological innovation

Variables	TFP	Inno	TFP
	(1)	(2)	(3)
Dif_{t-1}	0.118***	0.013	0.082***
	(4.67)	(0.07)	(2.97)
$Inno_{t-1}$			0.013***
			(3.09)
Count	270	270	270
adj_R^2	0.304	0.909	0.329

Table 7. Intermediary effects of technological innovation

	Coef	Z	P	Mediation effect ratio
Sobel	0.027	1.825	0.068	24.3%

5 Conclusions

Based on the mechanism of the inclusive, financial and technological characteristics of digital finance on the TFP of the real economy, this study uses 30 provinces from 2011 to 2020 to analyze the impact of digital finance on the TFP, using fixed effect models and intermediary effect models. Research has found that: firstly, digital finance development has markably improved the TFP level of China's real economy, among which the financial function of digital finance has the most significant impact on the TFP, and there is a U-shaped relation between technological nature and real economy; Secondly, from a regional perspective, digital finance has the strongest driving effect on the TFP in middle area. Although the facilities in east are complete, digital finance may be influenced by human factors and do not improve the real economy; Thirdly, technological innovation plays a partial mediating effect between digital finance and the TFP of the real economy.

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