

RESEARCH ARTICLE

IMPACT OF DIGITAL FINANCE ON TECHNOLOGICAL EFFICIENCY OF CREATIVE ENTERPRISES: EVIDENCE FROM CHINESE CAPITAL MARKET

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ABSTRACT

Digital finance plays a very important role in promoting the high-quality development of the Chinese economy. This article empirically examines the impact of digital finance on firms' technical efficiency by using the relevant data of Chinese digital creative listed companies from 2015 to 2020. The research findings indicate that digital finance has a significant positive influence on the technical efficiency of creative enterprises. The higher the level of digital finance development, the smaller the technical efficiency loss for the companies. Digital finance development not only reduces financial frictions and improves the financial mismatch of creative enterprises but also enhances innovation motivation by optimizing resource allocation. Therefore, accelerating the development of digital finance and expanding the scope of digital financial services can strengthen the positive incentive effect of digital finance on creative enterprises to improve technological efficiency, thus helping to promote the transformation of enterprises towards high-quality development.

KEYWORDS

Digital Finance; Creative Enterprises; Technical Efficiency; Financial Misallocation

1. INTRODUCTION

The Chinese economy is in a period of transition from high-speed development to high-quality development, where the traditional low-cost labor advantage is gradually weakening, and innovation has become an important driving factor for economic growth transformation (Romer, 1990). However, Chinese companies have relatively weak independent innovation capabilities (Tang et al, 2020). Although there is a large quantity of innovation output, the effectiveness of innovation achievements for enterprise development is limited. China has begun to vigorously promote the development of strategic emerging industries. In the "Classification of Strategic Emerging Industries (2018)" released by the National Bureau of Statistics of China, the digital creative industry is part of the strategic emerging industry. The creative industry is an industry characterized by creative thinking and innovative ideas, and with the progress of technology and globalization, the creative industry is gradually evolving towards digitization, networking, cross-border integration, and other directions. High-quality development pursues efficient growth, and the transformation of innovative creativity into technical efficiency requires substantial resource input, making sufficient and stable financial support a key factor for enterprise innovation and development (Wang et al, 2019).

Financial deepening theory suggests that the development of financial markets and institutions can reduce financing costs, provide more financing channels, facilitate efficient allocation of funds, and stimulate innovation investment and activities. Digital finance is a breakthrough innovation in traditional finance, representing a new financial model that integrates digital technology with modern financial industry. Although digital finance has a relatively short history, as an important application area of financial technology, it has received widespread attention and application worldwide. The international consensus reached at the 2016 G20 Summit called for prioritizing digital financial inclusion. The Chinese

government has also issued multiple policies to promote the digitization of financial services in an orderly manner. With its advantages of multiple financing channels, strong data analysis capabilities, and fast information processing speed, digital finance can effectively address the service imbalances in traditional financial services to the real economy (Yan, 2022), mitigate the financing constraints faced by enterprises in innovation, and thereby promote efficient growth (Huang, 2021).

2. THEORETICAL ANALYSIS AND RESEARCH HYPOTHESES

2.1 Impact of Digital Finance on Firm's Technical Efficiency

Neoclassical economics argues that capital is an important production factor for firms, and the absence of capital leads to resource waste and low technical efficiency. Midrigan et al. found that financial frictions can interrupt firms' technological innovation, inhibit the improvement of technical efficiency, and reduce its stability (Midrigan & Xu, 2014). Similar effects of financial frictions exist for other production factors as well (Buera, 2009). Stable sources and scale of funding are prerequisites for stable innovation investment and an inherent pillar for the steady improvement of firms' technical efficiency. When firms lack sufficient internal funds to meet the investment demands for innovation, effective external financing becomes an important means to smooth their innovation investment (Xie & Fang, 2011).

Digital finance has unique advantages in corporate financing, which can effectively reduce the adverse effects of financial friction. Firstly, it can effectively alleviate the problem of information asymmetry between financial institutions and enterprises. Secondly, it can broaden financing channels and lower the threshold for financial services. Finally, it can enhance financing efficiency and reduce financing costs by streamlining the credit approval process. As a strategic emerging industry characterized by high creative value and high technology, improving the

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efficiency of innovation investment is an important business goal for the creative industry. On the one hand, digital finance provides convenient financing channels, reducing the time and cost of corporate financing and efficiently meeting the funding needs for innovation investment. On the other hand, the technological advantages of digital finance enable rapid collection and processing of market information, helping enterprises and creditors effectively mitigate and control risks. Digital finance plays a significant role in incentivizing enterprise innovation and improving technical efficiency. Therefore, the following hypothesis is proposed:

Hypothesis 1: Digital finance contributes to improving the technical efficiency of creative enterprises.

2.2 Digital Finance, Financial Mismatch and Firm's Technological Efficiency

Financial mismatch is a manifestation of the inefficiency in financial markets. Financial mismatch can prevent firms from accessing innovation resources and result in low technical efficiency (Tian et al, 2021).

Financial mismatch can cause funds to flow to these enterprises and projects with sufficient funds, while other enterprises and projects that genuinely need funding and are conducive to improving production efficiency are unable to obtain financing. Moreover, financial mismatch increases the profitability of non-productive activities and weakens the willingness of enterprises to improve production efficiency through innovation activities (Zhao et al, 2021). For creative enterprises, constrained by their own resource endowments, high innovation risks, and difficulties in financing, they experience a higher degree of financial mismatch compared to other enterprises. Digital finance can alleviate the financial mismatch faced by creative enterprises through two pathways. Firstly, digital finance utilizes technologies such as cloud computing, big data, and blockchain to effectively aggregate scattered social funds and improve the efficiency of financial services (Demertzis et al, 2018). Secondly, digital finance generates technological spillover effects on other industries through information sharing and innovative concepts, enhancing enterprises' motivation for innovation. It can be seen that the degree of financial mismatch serves as an intermediary effect in the process of how digital finance influences the technical efficiency of creative enterprises. Therefore, the following hypothesis is proposed:

Hypothesis 2: Digital finance improves the technical efficiency of creative enterprises by alleviating financial mismatch.

3. RESEARCH DESIGN

3.1 Sample Selection and Data Source

This study selects Chinese digital creative listed companies from 2015 to 2020 as the sample. The classification criteria for the digital creative industry in the "Classification of Strategic Emerging Industries (2018)" published by the National Bureau of Statistics of China are used to identify the initial sample based on their main business operations. The following selection criteria are then applied: (1) Exclusion of ST and *ST companies; (2) Exclusion of companies with significant business changes during the sample period; (3) Exclusion of samples with abnormal or missing indicators. To avoid the influence of outliers, this study adopted Winsorization with a 1% trim on both ends of continuous variables. Finally, a total of 368 digital creative enterprises with 2061 observation samples are obtained.

3.2 Model Construction and Variable Definition

Currently, technical efficiency is mainly measured using two methods: Data Envelopment Analysis (DEA) and Stochastic Frontier Analysis (SFA). Compared to DEA, SFA incorporates random factors that affect output and allows for the introduction of various related factors to analyze individual efficiency differences. This article uses a stochastic frontier model to measure the technological efficiency of creative enterprises. Drawing on the research results of Green and Yang Xiuyun et al. , considering the innovative nature of creative enterprises, market promotion and R&D investment are added to the model (Greene, 2005; Yang et al, 2019). The model is constructed as follows:

$$\ln Y_{it} = \alpha_i + \beta_1 \ln k_{it} + \beta_2 \ln L_{it} + \beta_3 \ln R_{it} + v_{it} + \mu_{it} \tag{1}$$

Y is output, measured by the total operating revenue of the company for the year. L is labor input, measured by the average employee compensation for the year, reflecting the level of labor input by the company. K is capital input, measured by the average total assets at the beginning and end of the year. R is R&D and marketing investment, measured by the total sales and R&D expenses of the company for the year.

α_i is the individual effects of the company, measuring heterogeneity among companies. v_{it} is the random error term, following a normal distribution $N(0, \sigma_v^2)$. μ_{it} is the technical inefficiency term, following a truncated normal distribution $N^+(\mu_{it}, \sigma_{\mu}^2)$.

Based on the measurement of technical efficiency, in order to test Hypothesis 1 and Hypothesis 2, the following multiple linear regression models are constructed:

$$\ln \mu_{it} = \alpha_0 + \gamma_1 DIF_{it} + \gamma_2 SIZE_{it} + \gamma_3 AGE_{it} + \gamma_4 SC_{it} + \gamma_5 EDU_{it} + \varepsilon \tag{2}$$

$$FM_{it} = \alpha_0 + \gamma_1 DIF_{it} + \gamma_2 SIZE_{it} + \gamma_3 AGE_{it} + \gamma_4 SC_{it} + \gamma_5 EDU_{it} + \varepsilon \tag{3}$$

$$\ln \mu_{it} = \alpha_0 + \gamma_1 DIF_{it} + \gamma_2 FM_{it} + \gamma_3 SIZE_{it} + \gamma_4 AGE_{it} + \gamma_5 SC_{it} + \gamma_6 EDU_{it} + \varepsilon \tag{4}$$

Model (2) is used to test the impact of digital finance on technological innovation efficiency, models (3) and (4) are used to test the mediating effect of financial mismatch.

Where DIF represents the level of digital finance development. Referring to the research by Jiang Hongli and Jiang Pengcheng (Jiang & Jiang, 2021), the Digital Inclusive Finance Index published by Peking University Digital Finance Research Center is used to measure DIF. FM represents the degree of financial mismatch, which is calculated using the following formula based on the practices of Liu Binbin and Zuo Yonghua (Liu & Zuo, 2022):

$$\frac{RZ_t}{A_t} = \left(\frac{A_t - A_{t-1}}{A_{t-1}} - \frac{ROE_{t-1}}{1 - ROE_{t-1}} \right) (1 + \theta) \tag{5}$$

In Model (7), A is the total assets of the company at the end of the year, ROE is the return on equity, and RZ is the total external financing of the company. FM is measured by the absolute value of θ , and the larger the absolute value of θ , the higher the degree of financial mismatch.

In addition, this study selects firm size (SIZE), years since listing (AGE), ownership concentration (SC), and employee education level (EDU) as control variables.

4. EMPIRICAL RESULTS AND ANALYSIS

4.1 Measurement of Technological Efficiency in Creative Enterprises

The test results of Model (1) are shown in Table 1. The value of γ is 0.784 and significant at the 1% level, indicating the presence of technical inefficiency in the production and operation processes of Chinese creative enterprises, with the production function deviating from the optimal output. The value of η is 0.073, significant at the 10% level, indicating a significant annual variation trend in technological efficiency of creative enterprises from 2015 to 2020, but with a relatively small magnitude of change. The regression coefficients of all factors of production are positive and significant, indicating that labor input, capital input, and marketing and R&D investment have a positive impact on output, and increasing these three inputs in creative enterprises helps increase output. Among these three factors, the coefficient for capital input is the largest, followed by marketing and R&D investment, and the coefficient for labor input is the smallest. This suggests that the effect of output driven by low-cost labor is declining, and it is imperative for enterprises to seek high-quality development. At the same time, the quality of innovation in Chinese creative enterprises is not high, and the value of innovation converted into productivity is limited, indicating that the contribution of innovation to output still needs improvement.

Table 1: Test results of stochastic frontier production function			
vars	Coefficient	Std. err.	t
lnk	0.504***	0.031	19.53
lnL	0.084***	0.289	2.773
lnR	0.211***	0.061	34.60
cons	8.516***	0.102	5.052
σ^2	2.223***	0.033	66.64
γ	0.784***	0.277	8.617
μ	0.330***	0.099	3.321
η	0.073**	0.032	2.295

1 * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

According to the classification of the "Classification of Strategic Emerging Industries (2018)", the digital creative industry includes four major categories: digital creative technology equipment manufacturing, digital

cultural and creative activities, design services, and digital creativity and integration services. It covers industries such as intelligent consumer device manufacturing, remote sensing information services, digital publishing, and internet advertising services. From Table 2, it can be observed that there are differences in technological efficiency among the four subdivisions of the digital creative industry. The design services industry has the highest average efficiency, followed by the digital creative

technology equipment manufacturing industry, and the digital creativity and integration services industry has the lowest average efficiency. The digital creativity and integration services industry mainly includes advertising services, exhibition services, and digital publishing. The low technological efficiency indicates a high degree of homogeneity in the business content of this industry and a lack of innovation in business content.

Table 2: Technical efficiency estimation of the digital creative industry from 2015 to 2020

year	All	sub-sector1 ¹	sub-sector2 ²	sub-sector3 ³	sub-sector4 ⁴
2020	0.798	0.777	0.795	0.802	0.800
2019	0.784	0.786	0.782	0.791	0.784
2018	0.772	0.749	0.77	0.765	0.721
2017	0.757	0.759	0.756	0.759	0.753
2016	0.741	0.729	0.738	0.747	0.741
2015	0.724	0.734	0.721	0.757	0.719
Mean	0.763	0.756	0.760	0.77	0.753
STD	0.028	0.023	0.028	0.021	0.033

¹sub-sector1: Digital creative technology equipment manufacturing

²sub-sector2: Digital cultural creative activities

³sub-sector3: Design service

⁴sub-sector4: Digital creativity and integration services

4.2 Estimation and Testing of the stochastic frontier model

Considering that the stochastic frontier model estimation has multiple forms, it is necessary to use likelihood ratio testing to test the applicability of the model form before using it. The tests consist of two parts: testing the existence of technical inefficiency and testing the time-varying nature of technical inefficiency. By testing the existence of technical inefficiency, LR $\chi^2(1)=9.89$, Prob > $\chi^2=0.0017$, the results show that there is technical inefficiency in the operation process of Chinese creative enterprises. By testing the time-varying nature of technical inefficiency, LR $\chi^2(1)=20.48$, Prob > $\chi^2=0.0000$, indicating that the technical inefficiency values of Chinese creative enterprises vary over time. Therefore, this study is suitable for a time-varying model of technical inefficiency, and the subsequent empirical analysis will be based on this model.

To test the impact of digital finance on the technological efficiency of creative enterprises, Model (2) is constructed. In order to further verify the transmission path of the impact of financial factors on the technological efficiency of creative enterprises, models (3) and (4) were constructed, and the test results are listed in Table 3.

In the test results of Model (1), the coefficient of DIF is 0.029, significant at the 1% level, indicating a positive impact of digital finance on the technological efficiency of creative enterprises. The development of digital finance can improve the technological efficiency of creative enterprises, thus verifying Hypothesis 1. In the test results of Model (2), the coefficient of DIF is -0.014, significant at the 5% level, indicating a negative impact of digital finance on financial mismatch. The development of digital finance can reduce the degree of financial mismatch in creative enterprises. In the test results of Model (3), the coefficient of DIF is 0.027, and the coefficient of FM is -0.051, both significant at the 1% level. After considering the factor of financial mismatch, the coefficient of DIF decreases compared to the test results in Model (1), indicating that financial mismatch plays a partial mediating role in the impact of digital finance on the technological efficiency of creative enterprises, thus verifying Hypothesis 2. The reason for this may be that digital finance, through technological innovation transformation, reduces information asymmetry, improves financing efficiency, and promotes technological innovation in enterprises.

Table 3: Results of mediating effect test

vars	In μ		FM		In μ	
	Coefficient	t	Coefficient	t	Coefficient	t
DIF	0.029***	6.510	-0.014**	-1.890	0.027***	6.360
FM					-0.051***	-3.850
SIZE	0.118***	45.15	0.043***	9.970	0.115***	43.42
AGE	0.000	0.180	0.005***	7.880	-0.000	-0.490
SC	-0.021	-1.060	-0.125***	-3.910	-0.014	-0.730
EDU	-0.005	-0.510	-0.147***	-8.920	0.002	0.240
CON	-1.973***	-34.56	-0.567***	-5.970	-1.944***	-33.87
N	2061		2061		2061	
R2	0.535		0.136		0.538	
adj. R2	0.534		0.134		0.536	

¹* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

5. CONCLUSIONS

The development of digital finance has improved the efficiency of financial services, enhanced innovation motivation, and increased the technological efficiency of enterprises, thereby played a positive role in promoting high-quality development of the Chinese economy. The analysis of 368 listed

Chinese digital creative companies from 2015 to 2020 in this study reveals the following findings: for creative enterprises, capital investment has the highest contribution to output, followed by marketing and R&D investment, while labor input has the lowest contribution. The low quality of innovation hinders the sustainable development of enterprises. Digital finance has a significant positive impact on the technological efficiency of creative enterprises. The development of digital finance not only reduces financial frictions and improves the degree of financial mismatch in

creative enterprises, but also enhances resource allocation and stimulates their innovation enthusiasm. The higher the level of digital finance development, the smaller the loss in technological efficiency for enterprises.

This study offers the following implications: in order to enhance the technological efficiency of Chinese creative enterprises, it is necessary to value the continuous driving role of innovation in output. Efforts should be made not only to increase capital investment and improve the quality of innovation but also to actively promote industrial upgrading and change the way labor contributes. At the same time, financial institutions, as important external sources of financing for enterprises, should leverage the advantages of digital technology and proactively innovate financial services, building a digitized financial ecosystem that serves the development of the real economy. By providing convenient and efficient financing services, they can encourage enterprises to transform towards high-quality development.

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