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The Role of Digital Financial Inclusion in Promoting Entrepreneurship in China: A Provincial Perspective

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Abstract: This study examines the impact of DFI on entrepreneurship in China and across its regions (i.e., rural and urban) using province-level panel data from 2011 to 2019. Digital financial inclusion (DFI) serves as a catalyst for entrepreneurship by giving access to financial services. Entrepreneurs, both in urban centers and rural areas, gain fair and equitable platforms by unlocking opportunities for growth and innovation through the use of technology. We employed fixed effect Driscoll-Kraay standard errors (FE-DKSE) and feasible generalized least squares (FGLS) techniques for empirical analysis. The findings showed that there is an N-shaped relationship between the DFI and entrepreneurship in China and across its regions (i.e., rural and urban). Our estimates are robust and insensitive to the inclusion of other control variables such as economic growth, urbanization and trade openness. Economic growth and trade openness have a positive and significant impact on entrepreneurship, and a negative relationship between urbanization and entrepreneurship. The policy insinuation is that the government needs to actively expedite the growth of DFI and establish a favorable external environment for entrepreneurship. To enhance the attainment of entrepreneurial targets, it is essential to adapt DFI policies according to regions.

Keywords: China, Digital financial inclusion, Economic growth, Entrepreneurship.

1 | INTRODUCTION

The key element influencing household entrepreneurship is financial restrictions (King & Levine, 1993). Because starting a business often requires a specific amount of money, the majority of households lacking sufficient funds typically turn to conventional financial institutions like banks to secure financing and loans (Paulson & Townsend, 2004). But families with little money often have a tough time when they try to get help from banks or other places because the banks worry that they might not be able to pay back the money or that they might not use it wisely. This makes it hard for these families to get the money they need to start a business, especially if they don't have valuable things to offer as security for the loan, like a house or a car. In some places, there aren't even banks nearby, so it's even harder for families in those areas to get the money they need to start a business. This makes it tough for them to become entrepreneurs (Aiyar, Calomiris, & Wieladek, 2015; Beck & Demirguc-Kunt, 2006).

In the past few years, a new idea called "digital financial inclusion (henceforth DFI" has become popular. It's like a new way of doing banking that uses technology, and a lot of people are talking about it. They think it could be a way for families to get the money they need to start businesses, so it's getting a lot of attention as a cool financial innovation (Ahmad, Majeed, Khan, Sohaib, & Shehzad, 2021). DFI is a banking method that combines technology and financial services. One positive aspect of DFI is that it allows people in remote areas to easily set up bank accounts and use financial services on the internet. It does this by merging the technology of digital payment with the technology of mobile phones (Liu, Luan, Wu, Zhang, & Hsu, 2021). Additionally, DFI improves how clear, fast, and safe money transactions are by using credit scoring systems based on a lot of data. This makes it easier for banks and families to understand each other when they're dealing with money. It means more families and individuals can get loans, which is a big help for starting businesses at home (Ozili, 2018). Digital finance has several benefits as compared to traditional finance. It makes financial services available to more people, helps reduce the problem of not having enough information, and lowers the costs of doing financial transactions. Digital finance also solves the problem of being far away from banks by using a lot of data to give a detailed picture of a person's credit worthiness. This means it can offer services to people who usually don't get help from regular banks (Berg, Burg, Gombović, & Puri, 2020; Klapper, 2023).

DFI has three main benefits when it comes to encouraging household entrepreneurship: extensive coverage, wide use, and being highly digital (Ahmad et al., 2021). Firstly, growing availability of accounts for digital transactions means that people in faraway areas, who might have a hard time getting regular banking services, can now use the internet and mobile phones to access the financial services they need (Liu et al., 2021). Secondly, when DFI is used more deeply, it not only boosts the number of households that are using financial services but also continually gathers digital records of users of services like payments. This, in turn, can reveal borrowers credit histories to financial institutions, making it easier for them to access loans (Berg et al., 2020). Lastly, highest level of digitalization in DFI highlights its regional advantages. In simple terms, using mobile payments makes transactions faster, reduces wasting time, and saves money on transactions (Beck, Pamuk, Ramrattan, & Uras, 2018).

Digital finance has the power to enhance the effectiveness of financial systems, leading to more opportunities for entrepreneurship (Baden-Fuller & Haefliger, 2013). Demonstrates the influences of mobile payments upon the entrepreneurship by utilizing a model that considers the broader economic context (Ahmad et al., 2021). Offers proof that digital finance supports household entrepreneurship by spreading information effectively (Yin, Gong, Guo, & Wu, 2019). Entrepreneurship plays a vital role in China's efforts to reform its supply-side structure. It can speed up economic growth, improve and modernize industries, and facilitate economic change (Hu & Zhang, 2014).

In recent times, entrepreneurship in China has undergone significant transformations, especially with the rapid advancement of online businesses. The widespread adoption of mobile payment methods plays a crucial role in driving these changes. Both consumers and businesses increasingly rely on mobile payments. Through the use of the internet, large data, and further technology, phone payments have successfully lowered the transaction costs associated with financial services and broadened the range of available financial services (Xie, Zou, & Liu, 2014). Academics are particularly interested in understanding the factors that influence entrepreneurship. This interest stems from the fact that entrepreneurship plays

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a dual role: it drives economic growth and offers solutions to employment challenges in developing nations (De Mel, McKenzie, & Woodruff, 2008). Entrepreneurship is about enterprising individuals finding and making the most of profitable opportunities (Shane & Venkataraman, 2000). It often shows through the establishment and administration of new businesses (Sarason, Dean, & Dillard, 2006). People commonly view entrepreneurship as a significant catalyst for sustained economic growth, as it fosters innovation (Li, Xu, & Li, 2020; Pradhan, Arvin, Nair, & Bennett, 2020). It also plays a crucial role in generating substantial employment opportunities (Peinado y Miguel & Rodriguez Barba, 2020). Due to its importance in driving economic growth, entrepreneurship has become a central focus for both academic research and policymaking. As China undergoes a period of transition and rapid urbanization, it encounters substantial challenges related to job creation, upgrading industries, and transforming its economic structure. Entrepreneurship as a key catalyst in this process (McMillan & Woodruff, 2003), plays a crucial role in addressing these challenges by improving resource utilization, encouraging innovation, and fostering healthy market competition, among other things (Gries & Naudé, 2010; Webb, Bruton, Tihanyi, & Ireland, 2013).

China, in its role as a developing nation, has placed considerable importance on the growth of DFI. At the start of 2015, the Chinese State Council unveiled the "Strategy for Promoting Inclusive Finance Development (2016-2020)," which outlined the path for financial institutions. In the following government reports for 2016-2017, the growth of DFI was consistently encouraged to improve access to financial services for entrepreneurs. Supported by various policy and technological advancements, DFI steadily increased its reach, leveraging technologies. According to the 2021 World Bank fin-tech report, China's fin-tech companies are valued at a total of $30 trillion, with a user base of 200 million, making China a global leader in this field. It's clear that DFI had a significant influence on entrepreneurship among households in China (Efma, 2021).

Looking at it from a local perspective, data from the CAICT (China Academy of Information and Communication Technologies) reveals that digital economy of China was valued at 22.4 trillion yuan in 2016 and had grown to 35.8 trillion yuan in 2019. This accounted for 36.2% of the GDP and saw a year-on-year growth of 15.6%, significantly outpacing the GDP growth rate (CAICT, 2020). The percentage of female entrepreneurs in China rose from 20% to 25% between 2005 and 2015 (Ahmad et al., 2021). China has been working to create a supportive environment for entrepreneurship and has encouraged various organizations to participate in innovation and business startups. Recent statistics indicate that as of the end of 2020, there were a total of 13.20 million private enterprises and individual businesses in China, making up 99.60% of the overall number of enterprises (Zheng, Wu, & Zhang, 2017). The predominance of men in entrepreneurship has decreased. They found that in China 48.8%, of individuals identifying as entrepreneurs were women, while 51.2% were men, suggesting a relatively minor gap in gender (Li, Liu, Belitski, Ghobadian, & O'Regan, 2016). Approximately 42-45% of social enterprises are led by women, even though the overall reported ratio of women entrepreneurs is 25% (Warnecke, 2018). The 2017 global Findex report revealed that between 2014 and 2017, just about 515 million individuals worldwide opened accounts in banks using traditional finance institutions and phone services. This represents a rise from 62 percent to 69 percent of people with accounts. However, the adoption of financial technology (Fin-tech) varies in 27 countries. India and China are at the forefront with an adoption rate of 87%, while Japan has the lowest adoption rate at 34% (Ahmad et al., 2021). Over the last 5 to 10 years, digital economy of China, particularly digital finance, has experienced swift growth thanks to technological innovation such as big data. Notable developments include the rise of Alipay (Gabor & Brooks, 2020). In 2019, a total of 633 million people in China used Alipay and Wechat for online payments, marking an increase of 32.65 million compared to December 2018. This indicates a significant surge in mobile payments within China (Ahmad et al., 2021). From 2007 to 2020, the number of people who used internet in China surged from 210 million to 940 million, while the penetration value of internet rose from 16% in 2007 to 67% in 2020 (Luo & Li, 2022). According to the Peking University DFI Index of China (PKU-DFIIC), overall DFI index of China has grown significantly, going from 40 in 2011 to 334.8 in 2020. DFI has proven effective in reducing transaction expenses due to its favorable attributes like affordability, extensive accessibility, and strong efficiency (Lu, Lai, & Zhang, 2023).

As per the Peking University DFI Index of China (PKU-DFIIC), at the municipal level, the average digital financial inclusion index in China has shown notable growth. It stood at 155.35 in 2013, increased to 220.01 in 2015, and further rose to 271.98 in 2017. This signifies a swift development of DFI within a relatively short span of time (Du, Zhou, Yang, & Du, 2023). Data from the NBS of China reveals that in the last ten years, the population of rural migrant workers in China who have moved away from their hometowns increased from 163.36 million in 2012 to 171.72 million in 2021. These migrant workers face disparities with local urban households concerning income, assets, housing, and social security. For instance, data from the NBS of China shows that in 2020, rural migrant workers who had moved away from their hometowns had an average monthly income of RMB 4,549. Even those who worked year-round only earned an average annual income of RMB 54,588. In contrast, urban employees had an average annual salary of RMB 77,553 in 2020, which is 1.42 times higher than that of rural migrant workers (Peng & Mao, 2023). As stated in the global entrepreneurship monitor of the years 2016 and 2017 in detail on the entrepreneurship of females, between 2014 and 2016, 163 million women in 74 countries were initiating new businesses, and 111 million were managing existing ones. In comparison to the 2014 report, women's "Total Entrepreneurship Activity" (TEA) had increased by 10%, and the ownership of establishing businesses by women had risen to 8% (Kelley et al., 2017).

The contributions of this study are as follows: Firstly, by investigating the impact of DFI on the entrepreneurship utilizing Chinese provincial data of 30 provinces and using a better proxy of entrepreneurship (measured by the average number of self-employed) as compared to previous studies (He, Ma, & Gan, 2022; Li, Tan, Wu, & Yu, 2022; Liu, Koster, & Chen, 2022; Liu et al., 2021; Mao, Wang, & Zhu, 2023; Peng & Mao, 2023; Yin et al., 2019; Zhao, Jiang, & Yin, 2020)[1] those used the probability of being self-employed as proxy of entrepreneurship. Secondly, we use a longer time period and provincial panel data, covering the years 2011 to 2019 as compared to previous existing literature (He et al., 2022; Liu et al., 2022; Liu et al., 2021; Mao et al., 2023; Peng & Mao, 2023; Yin et al., 2019; Zhao et al., 2020) that used 1 or 2 household survey data, and Li et al. (2022) used dynamic household survey of 2012-2017 for empirical analysis. Contrary to these findings, two notable studies used different proxies for entrepreneurship and distinct periods of Chinese data. Cao and Zhang (2022) used self-employment growth rate calculated by regional individual and private enterprise employment or regional total employment population as a proxy for entrepreneurship using data from 2005 to 2016, and Jiang and Fan (2022) utilized an entrepreneurial activity index measure as private enterprise entrepreneurs in rural areas + self-employed entrepreneurs in rural areas or total number of adults aged 18-64 years in rural areas with Chinese data spanning from 2006 to 2013. These studies employed traditional measures of financial inclusion, but our measure is not traditional but more comprehensive measure, so their proxies (for entrepreneurship and FI) and time periods are different from our approach. Thirdly, our study employs a more comprehensive measure of DFI, including breadth of coverage, depth of use, and level of digitalization. Fourth, as there are differences between urban and rural economic landscapes (Ding, Li, & Zhu, 2023; Mao et al., 2023), we also analyze the impact of DFI on entrepreneurship in urban and rural samples. As Chinese regions are different

[1]Used household survey data and utilized probability for self-employed if they are engaged in the entrepreneurship activities.

regarding development level and resource endowments (Dou, Ul-Haq, Visas, Aslam, & Khanum, 2023; Jiang, Wang, Ren, & Xie, 2023; Shi, Visas, Ul-Haq, Abbas, & Khanum, 2023; Tao, Zhang, & Shangkun, 2022; Ul-Haq, Mushtaq, Visas, & Hye, 2023), we further segregate our sample into eastern, central, and western. By bridging the gap in the current literature, our research provides valuable insights for both scholars and policymakers.

The remainder of this paper is organized as follows: Section 2 describes the theoretical framework, and Section 3 presents the literature review and research hypothesis. Section 4 presents the data and methodology, while Section 5 presents results and discussions, and Section 6 presents the conclusion and provides policy implications.

2 | THEORETICAL FRAMEWORK

Entrepreneurial growth consists of knowledge transfer and market exploration. In this argument, the resource-based theory (RBT) of entrepreneurship (Alvarez & Busenitz, 2001) clarifies the conditions governing the transfer of resources and capabilities into novel knowledge and products. To identify and substantiate opportunities, existing capabilities must be combined with resources and technologies, encompassing cloud technology, mobility, social media, big data analytics, robotics, the Internet of Things, and artificial intelligence, particularly during the stages of market entry and growth (Audretsch & Belitski, 2021; Li & DaCosta, 2016).

Resource-Based Theory provides a framework for understanding how the unique resources offered by digital financial inclusion play a crucial role in fostering entrepreneurship, driving innovation, and ultimately contributing to economic development. RBT suggests that digital financial inclusion enhances entrepreneurship by providing entrepreneurs with unique and valuable resources. Within the framework of RBT, digital financial tools and platforms serve as essential assets, offering entrepreneurs access to robust financial infrastructure. Digital payment systems and mobile banking, among other key resources, play a crucial role in enhancing financial capabilities. These technologies enhance entrepreneur's financial management capabilities, access to credit, and overall business decision-making. This, in turn, enables them to effectively manage their finances, conduct transactions, and access essential credit services. The inclusive nature of digital financial services broadens market opportunities, aligning with RBT's emphasis on leveraging unique resources for a sustainable competitive advantage.

Startup enterprises recognize the value of leveraging social media applications and other digital technologies as an integral part of their resource portfolio. According to the Resource-Based View (RBV) theory, (SMEs) that concurrently employ advanced technologies like AI, big data analytics, and block chain are expected to outperform their counterparts in the same market (Chatterjee, 2021). To elucidate how SMEs that adoption of digital technology leads to enhanced performance and the augmentation of economic and social value, this study draws upon the RBV theory (Barney, 1991).

3 | LITERATURE REVIEW AND RESEARCH HYPOTHESIS

3.1 | Digital Financial Inclusion and Entrepreneurship

Insufficient funds pose a barrier to entrepreneurial activities (Beck & Demirguc-Kunt, 2006). Financial constraints impact both the decisions of individual entrepreneurs and the scale of development for their businesses (Ozili, 2022). Because many households lack the capacity to offer extensive financial information and sufficient collateral during the initial phases of starting a business, banks may not be the most suitable source for external funding (Harrison, Li, Vigne, & Wu, 2022). Numerous traditional financial institutions often impose stringent qualification criteria and elaborate application procedures, which could be challenging for households to fulfill or navigate. Consequently, this can lead to financial exclusion (Kaiser, Lusardi, Menkhoff, & Urban, 2022). DFI plays a crucial role in advancing FI by diminishing information disparities within financial markets, broadening the scope of clientele covered by financial services, and ensuring that marginalized financial services are equally accessible to groups in remote areas (Ahmad et al., 2021; Ozili, 2018).

In three key ways, DFI empowers households to engage in the finance market. It provides easier access to information on managing money and investing. Instead of having to meet people physically, households can utilize the mobile internet and mobile devices to rapidly learn about the allocation of financial assets. This means they have the potential to enhance their financial understanding without being limited by where they are or what time it is. This makes the information they receive more accurate, giving them better chances in the financial market. To invest in things like stocks, funds, and bonds, you usually need to open an account. DFI, particularly mobile payments, enables households to do this and make transactions online. This makes it a lot more convenient for them to get involved in the financial market, and it saves their time. Digital financial inclusion offers more options for households when it comes to investing their money. It's like it widens the range of choices available to them, thanks to its wide accessibility (Ren & Li, 2019).

DFI addresses the limitations of traditional financial services through innovation founded on scenarios, data, and information. It maximizes the advantages of broad accessibility, affordability, and speed. This effectively eases the financial constraints faced by disadvantage groups, including impoverished farmers and small rural businesses (Aisaiti, Liu, Xie, & Yang, 2019; Y. Liu et al., 2021; Y. Luo & Zeng, 2020). They assert that growth of digital finance has a calming and equalizing effect on the business atmosphere and chances for entrepreneurs in rural areas. DFI provides a comparatively straight-forward and practical means of financial inclusion for households with low income, empowering them to overcome the entrepreneurship barriers that are relevant (Luo, Peng, & Zeng, 2021).

H1: *DFI has positive influence on entrepreneurship.*

3.2 | Digital Financial Inclusion and Economic Growth

Numerous studies have highlighted the hurdles faced by traditional financial systems due to information imbalances and costly transactions, hindering their ability to facilitate economic development (Murinde, 2012; Yeung, 2009). In the context of credit rationing theory, the presence of information asymmetry complexes the attainment of a balance between receivers and providers. Consequently, this hampers the ability of traditional financial institutions to efficiently foster the expansion of the real economy (Beisland, Djan, Mersland, & Randøy, 2021; Khafagy, 2019). The transaction cost theory underscores the limitations of traditional financial institutions when it comes to assisting vulnerable groups like small and micro-enterprises (Sardo, Serrasqueiro, & Armada, 2022; Scannella, 2015). These limitations arise because it costs more to serve these groups, and the profits are lower. However, by harnessing digital technology, DFI brings about a significant change from traditional finance and tackles the obstacles related to information imbalances and the cost of transactions (Xue, Zhu, Zhao, Wang, & Li, 2019; Zhao, Li, & Pan, 2015). DFI improves

access to and affordability of financial services, which has a positive impact on vulnerable groups. It improves the quality of economic growth in three main ways. Firstly, the adoption of advanced technology in DFI leads to the creativity of traditional financial goods and services, lowers the cost of financial services, and broadens the reach of finance-related services to customers. This contributes to the long-term sustainability of the actual economy (Ong, Wasiuzzaman, Chong, & Choon, 2023). Furthermore, they play a crucial role in aggregating dispersed resources within society, catering to the needs of niche markets, and effectively addressing the mismatch between supply and demand in financial markets. It also extends its reach to underdeveloped regions and low-income segments, contributing to more balanced economic development across different regions (Yu & Wang, 2021). Moreover, DFI can alleviate constraints by offering accessible investment products, tapping into latent demand of consumers, and mobilizing not-in-use funds within society, thereby promoting economic development (Yu & Wang, 2021).

DFI can stimulate the growth of economy through several avenues, Schneider (2018) points out that when enterprises, financial service providers, and government organizations shift away from reliance on physical currency and documented records in their day-to-day activities, they experience significantly improved operational efficiency, leading to substantial increases in income and savings. Additionally, digital financial inclusion reduces the cost of the financial services. According to a report by the MC-Kinsey Global Institute, financial service providers offering digital accounts to customers can reduce costs by 80% to 90% compared to traditional banks. This makes digital channels a viable option for users with low incomes, and even despite having low account balances and limited transaction volumes, they can be profitable for service providers. As a result, DFI delivers advantages to both people and communities.

H2: *DFI has positive influence on economic growth.*

4 | DATA AND METHODOLOGY

4.1 | Data

To examine the impact of digital financial inclusion on entrepreneurship, this study utilizes panel data from 30 provinces in China for a period of 9 years, from 2011 to 2019. This study compiles the data on entrepreneurship, digital financial inclusion, and other control variables like economic growth, urbanization and trade openness. Average number of self-employed is used as a proxy for entrepreneurship; for the overall case, OSE (Overall Self-Employed), RSE (Rural Self-Employed), and USE (Urban Self-Employed), are used as dependent variables, based on data collected from the China National Bureau of Statistics (CNBS), China Statistical Yearbook, and digital financial inclusion index data obtained from Peking University. Table 1 presents the variables used in the study along with their corresponding descriptions.

Table 1: Description of variables.

Variable	Code	Explanation
Entrepreneurship	ENTREP (OSE, RSE, USE)	Average number of self-employed
Digital financial inclusion	DFI	Digital inclusive finance index
Economic growth	EG	GDP per ca-pita
Urbanization	URBAN	Share of urban population
Trade openness	RTO	Trade to GDP ratio

4.2 | Methodology

Our research examines the impact of digital financial inclusion on entrepreneurship in China using fixed effects, Driscoll-Kraay standard errors (FE-DKSE), and FGLS estimator for coefficient estimates. In this study, we identify the problems of heteroscedasticity and cross-sectional dependence within the data set. To solve these problems, we apply the diagnostic tests, which are modified Wald test and Pesaran test, respectively. We utilize the Driscoll-Kraay standard errors (DKSEs) method, as proposed by Le, Le, and Taghizadeh-Hesary (2020), to investigate the correlation between DFI and ENTREP. This analysis was conducted for China as a whole. Additionally, we utilize robust standard errors recommended by Driscoll and Kraay (1998) for panel datasets with cross-sectional dependence (CSD) to ensure the reliability of our findings. Empirical analysis was also conducted using the fixed-effect Driscoll-Kraay standard errors (FE-DKSE) methods. In our study, we utilize a core panel model, which can be represented as follows:

$$ENTREP_{pt} = \beta_0 + \beta_1 DFI_{pt} + \beta_2 DFI^2{}_{pt} + \beta_3 DFI^3{}_{pt} + \varepsilon_{pt}$$

After the control variables were included, the complete panel model use in our study can be represented as:

$$ENTREP_{pt} = \beta_0 + \beta_1 DFI_{pt} + \beta_2 DFI^2{}_{pt} + \beta_3 DFI^3{}_{pt} + \beta_4 EG_{pt} + \beta_5 URBAN_{pt} + \beta_6 RTO_{pt} + \varepsilon_{pt}$$

In the given panel model, the p and t refer to province and time, respectively. *ENTREP* refers to entrepreneurship; *DFI* refers to the digital financial inclusion index. *EG* is economic growth, *URBAN* is urbanization and *RTO* is trade openness. The error term, denoted as ε, satisfies the normality assumptions in the model, implying that it follows a normal distribution. The coefficient β_0 represents a constant term, while β_1 to β_6 are the coefficients associated with digital financial inclusion, economic growth, urbanization and trade openness, respectively. We measure the primary explanatory variable in our study, *DFI* using Peking University's digital inclusive financial index. To measure *ENTREP*, we use average number of self-employed as a proxy for entrepreneurship. For the *DFI* measurement, we use the digital financial inclusion index as an explanatory variable, as suggested by Mao et al. (2023) and Shao, Ma, and Kamber (2023), which have a positive impact on entrepreneurship. We use GDP per ca-pita to measure the economic growth used by Ahmad et al. (2021), which shows a positive relationship between economic growth and *DFI*. We use share of urban population as a proxy for urbanization used by Shi et al. (2023) and the trade to GDP ratio as a proxy for trade openness, as used by Jun, Mahmood, and Zakaria (2020).

5 | RESULTS AND DISCUSSION

Table 2 represents the descriptive statistics of the variables. To capture and evaluate essential aspects of both rural and urban economic contexts. These variables include Overall Self-Employed (OSE), Rural Self-Employed (RSE) and Urban Self-Employed (USE). To gauge the extent of digital financial inclusion, we utilize the Log of Digital Financial Inclusion (LDFI). Additionally, there is Log of Breadth of Coverage (LBOC), Log of Depth of Usage (LDOU), and Log of Degree of Digitalization (LDOD). Lastly, LGDPPC stands for Log of gross domestic product (GDP) per Capita. The mean and standard deviation of the OSE are 402.448 and 318.028, respectively. The standard deviation is smaller than the mean value. This indicates a dispersion of data around the mean. In the whole sample of Chinese provinces, the lowest OSE is 28.84 and highest rate is 1849.7. We further examine the rural self-employed and urban self-employed. The mean value of the RSE is 137.133, and the standard deviation is 147.928. The value of standard deviation is higher than the mean value, which means that the data is not spread around the mean. Its minimum value is 1.6, and its maximum value is 1204.4. The mean and standard deviation of the USE are 265.314 and 208.072, respectively. The standard deviation is smaller than the mean value. This indicates a dispersion of the data around the mean. In the whole sample of China provinces, the smallest USE is 22.49 and highest rate is 1166.2. The mean value of the LDFI is 5.151, and the standard deviation is .6701. If the value of standard deviation is smaller than the mean value, it means that the data is spread around the mean. Its minimum value is 2.908, and its maximum value is 6.0168. We further explore the three dimensions of DFI. The mean value of the LBOC is 4.995, and the standard deviation is .8268. If the value of standard deviation is smaller than the mean value, it means that the data is spread around the mean. Its minimum value is .6729 and its maximum value is 5.952. The LDOU has a mean of 5.133 and a standard deviation of .6456. This indicates the dispersion of data around the variable's mean. The minimum value of LDOU is 1.911, and the maximum value is 6.086. The mean and standard deviation of LDOD are 5.457 and .7162, respectively. If the value of standard deviation is smaller than the mean value, it means that the data is spread around the mean. The mean and standard deviation of URBAN are .5815 and .1251, respectively. If the value of standard deviation is smaller than the mean value, it means that the data is spread around the mean. If the mean value of the LGDPPC is 10.811 and the standard deviation is .4334. The value of standard deviation smaller than the mean value it means that the data is spread around the mean. The mean value of the RTO is .2790, and the standard deviation is .2967. If the value of standard deviation is higher than the mean value, it means that the data is not spread around the mean.

Table 2: Descriptive statistics.

Variable	Obs.	Mean	Std. dev.	Min.	Max.
OSE	270	402.448	318.028	28.84	1849.7
RSE	270	137.133	147.928	1.6	1204.4
USE	270	265.314	208.072	22.49	1166.2
LDFI	270	5.151	0.6701	2.908	6.0168
LBOC	270	4.995	0.8268	0.6729	5.952
LDOU	270	5.133	0.6456	1.911	6.086
LDOD	270	5.457	0.7162	2.025	6.136
URBAN	270	0.5815	0.1251	0.3503	0.9376
LGDPPC	270	10.811	0.4334	9.7058	12.008
RTO	270	0.2790	0.2967	0.01277	1.463

We used different approaches for comparison and robustness checks. Prior to estimation, we use the Pesaran test for the cross-sectional dependence and modified Wald test for heteroscedasticity separately on the OSE, RSE, and USE. The results in Table 3 suggest the existence of cross-sectional dependence and heteroscedasticity, as the chi 2 and F statistics are significant at the 1% and 5% levels, except value of use from Pesaran test is insignificant.

Table 3: Heteroscedasticity and cross-sectional dependence diagnostic tests.

Test	Error process	Test statistics		
		OSE	RSE	USE
Pesaran test	Cross sectional dependence	2.018**	3.399***	0.279
Modified Wald test	Heteroskedasticity	20962.18***	1.5e+05***	46237.82***

Note: The number of '***' shows the significance level, with '***' representing 1%, and '**' denoting 5%.

The study estimates the models with the robust standard errors suggested by Driscoll and Kraay (1998) and a cross-sectional dependence for panel data. The Table 4 shows the Pesaran (2004) CD test because of the existence of cross-sectional dependence in the data. There are three columns showing the overall, rural and urban analysis for all variables. All of these values are statistically significant at 1% level.

Table 4: Pesaran (2004) CD test for CSD in panel data.

Variable	CD-test		
	Overall	Rural	Urban
ENTREP	48.96***	18.84***	44.41***
LDFI	62.38***	62.38***	62.38***
URBAN	52.20***	52.20***	52.20***
LGDPPC	51.22***	51.22***	51.22***
RTO	21.62***	21.62***	21.62***

Note: Under the null hypothesis of cross-sectional dependence, p-values close to zero represents data are correlated across panel groups.
The number of '***'shows the significance level, with '***' representing 1%.

To estimate the impact of DFI on entrepreneurship, we utilize a panel regression model with fixed effect Driscoll-Kraay standard errors (FE-DKSE) and also apply feasible generalized least squares (FGLS) in our study by using provincial-level panel data from China.

Table 5: Digital financial inclusion and entrepreneurship (Robustness check).

	FE-DKSE								FGLS		
	Overall			Rural			Urban		Overall	Rural	Urban
Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
LDFI	4,715***	6,476***	3,604**	3,660*	1,507***	1,269*	3,208***	2,391*	4,638***	1,412***	2,923***
	(829.3)	(1,571)	(1,314)	(1,669)	(262.4)	(623.2)	(619.9)	(1,068)	(984.0)	(427.8)	(849.8)
$LDFI^2$	-1,123***	-1,525***	-857.2**	-889.5**	-359.3***	-307.1*	-763.7***	-582.5**	-1,105***	-340.4***	-696.1***
	(185.1)	(353.4)	(285.1)	(368.9)	(57.72)	(137.9)	(139.3)	(236.3)	(220.0)	(96.18)	(187.4)
$LDFI^3$	88.68***	119.1***	67.46**	71.84**	28.41***	24.72**	60.27***	47.12**	87.11***	27.17***	54.88***
	(13.44)	(25.94)	(20.12)	(26.57)	(4.130)	(9.923)	(10.16)	(17.03)	(16.07)	(7.062)	(13.54)
URBAN		-501.8***	-1,986***	-2,548***		-1,064***		-1,484***			
		(132.9)	(235.2)	(113.9)		(52.58)		(80.21)			
LGDPPC			559.8***	517.2***		211.1***		306.1***			
			(55.94)	(44.89)		(18.20)		(27.57)			
RTO				311.5***		113.7***		197.8***			
				(23.40)		(16.93)		(17.43)			
Constant	-6,282***	-8,571***	-9,589***	-8,931***	-2,001***	-3,348***	-4,281***	-5,583***	-6,154***	-1,847***	-3,878***
	(1,199)	(2,215)	(1,793)	(2,303)	(384.6)	(893.8)	(890.7)	(1,444)	(1,432)	(618.7)	(1,258)
F/w-stat	2673.22	5192.67	15199.33	14347.61	676.91	8903.11	4984.00	14319.07	322.29	136.96	213.30
P-value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Note: In all FE-DKSE models, ENTREP serves as the dependent variable. The robust standard errors are displayed in parentheses.
The number of '***' shows the significance level, with '***' representing 1%, '**' denoting 5%, and '*' indicating 10%. N is 270 in all models and no of groups is 30 in all models.

Table 5 Illustrates the fixed effect Driscoll-Kraay standard errors (FE-DKSE) technique to check if the relationship between entrepreneurship and digital financial inclusion (DFI) is indeed N-shaped. The first 8 columns are an analysis of (FE-DKSE), in which the 1 to 4 columns represent the overall self-employed, 5-6 represent rural self-employed results, and 7-8 columns represent urban self-employed. The analysis reveals that the coefficient of LDFI in the first column is positive (4715), the coefficient of $LDFI^2$ in the first column is negative, and the coefficient of $LDFI^3$ in the first column is positive (88.68). These coefficients are statistically significant at 1% level. This suggests a significant positive relationship between DFI and entrepreneurship in China. In all columns, the values of the LDFI are positive, the values of DFI^2 in all other columns are negative, and the values of $LDFI^3$ in other columns are positive. Across all components of DFI, the first term indicates a rise, while the second term shows a decrease, and the third term shows an increase, suggesting an overall N-shaped relationship. This supports the hypothesis that there is an N-shaped relationship between DFI and entrepreneurship in China as a whole. We incorporated various control variables into our baseline model as a measure of robustness. The control variables include urbanization, economic growth, and trade openness, as they are major factors in entrepreneurship. In column 2, we use share of urbanization as a proxy for urbanization; the coefficient of URBAN is negative (-501.8). Our findings are consistent with Dou et al. (2023); Shao et al. (2023) and Shi et al. (2023) contrast with Jiang et al. (2023) and Ul-Haq, Visas, Hye, Sam, and Hameed (2023). In column 3 we use log of GDP per capita for economic growth the coefficient of this is positive (559.8). Our findings are consistent with Shi et al. (2023) and Mao et al. (2023), in contrast with Dou et al. (2023); Shao et al. (2023), and Yang, Huang, and Gao (2022). In column 4, use the trade-to-GDP ratio for trade openness; the coefficient for this variable is positive (311.5). All these coefficients are statistically significant at 1% level. Our findings are consistent with Bayar, Gavriletea, and Ucar (2018) and Dilanchiev and Sekreter (2015). The 5-6 columns are rural self-employed. In column 5, the coefficient of LDFI is positive (1507), coefficient of $LDFI^2$ is negative (-359.3), and the coefficient of $LDFI^3$ is positive (28.41). In column 6 the URBAN coefficient is negative (-1064), the LGDPPC coefficient is positive (211.1), and the RTO coefficient is positive (113.7). In columns 7 and 8, which represent urban self-employment, the coefficient of DFI is positive (3208). These coefficients are statistically significant at 1% level, including the coefficient of URBAN, LGDPPC, and RTO, which are statistically significant in column 8. Further, we estimate the FGLS, and the results of FGLS are in columns 9, 10, and 11. The column 9 represents the overall self employed and the coefficient of LDFI is positive (4638), the coefficient of $LDFI^2$ is negative (-1105), and the coefficient of $LDFI^3$ from column 9 is positive (87.11). The column 10 represents the rural self-employed, the coefficient of LDFI is positive (1412), coefficient of $LDFI^2$ is negative (-340.4) and the coefficient of $LDFI^3$ is positive (27.17). The column 11 represents the urban self-employed, the coefficient of LDFI is positive (2923), the coefficient of $LDFI^2$ is negative (696.1), and the coefficient of $LDFI^3$ is positive (54.88). These coefficients are statistically significant at 1% level. The results of FGLS also show that there is an N-shaped relationship between DFI and entrepreneurship in China.

Table 5a: Digital financial inclusion and entrepreneurship (BOC) (FE-DKSE).

Variable	Overall				Rural	Urban
	(1)	(2)	(3)	(4)	(5)	(6)
LBOC	703.7***	805.3***	480.1***	558.1***	181.2***	376.9***
	(68.55)	(179.6)	(65.84)	(79.60)	(36.25)	(45.65)
$LBOC^2$	-229.0***	-260.2***	-158.2***	-188.2***	-61.46***	-126.7***
	(25.14)	(62.26)	(23.38)	(25.63)	(12.00)	(14.26)
$LBOC^3$	23.70***	27.12***	16.39***	20.08***	6.628***	13.45***
	(2.620)	(6.269)	(2.404)	(2.400)	(1.123)	(1.322)
URBAN		-466.7***	-2,043***	-2,574***	-1,074***	-1,500***
		(86.24)	(232.6)	(111.9)	(56.18)	(73.86)
LGDPPC			591.1***	554.0***	222.6***	331.5***
			(55.79)	(34.79)	(16.08)	(19.30)
RTO				286.6***	106.6***	180.0***
				(23.82)	(16.74)	(18.55)
Constant	-410.8***	-304.0**	-5,335***	-4,819***	-1,890***	-2,929***
	(47.13)	(98.72)	(444.2)	(291.4)	(143.4)	(152.8)
Stat	559.19	5483.72	6324.54	38877.01	27121.88	45461.15
P-value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Note: In all FE-DKSE models, ENTREP serves as the dependent variable. The robust standard errors are displayed in parentheses.
The number of '***' shows the significance level, with '***' representing 1%, and '**' denoting 5%.

We also evaluate the impact of DFI on entrepreneurship further through three main categories: breadth of coverage (BOC), depth of usage (DOU), and degree of digitalization (DOD). Table 5a evaluates the impact of DFI on entrepreneurship through breadth of coverage (BOC). Columns 1 to 4 represent the overall self-employed, and in column 1, the coefficient of LBOC is positive (703.7), the coefficient of $LBOC^2$ is negative (-229.0), and the coefficient of $LBOC^3$ is positive (23.70). In column 2, the coefficient of URBAN is negative (-466.7). In column 3, the coefficient of LGDPPC is positive which is (591.1). In column 4, the coefficient of RTO is positive (286.6). While the columns 5 and 6 show the rural self-employed and urban self-employed respectively. Both columns exhibit both positive and negative values that are statistically significant. The positive coefficient suggests that an increase in DFI is associated with a corresponding increase in entrepreneurship in China, while the negative value suggests that an increase in DFI is associated with a corresponding decrease in entrepreneurship in China. All the coefficients are statistically significant at the 1% level.

Table 5b: Digital financial inclusion and entrepreneurship (DOU) (FE-DKSE).

Variable	Overall				Rural	Urban
	(1)	(2)	(3)	(4)	(5)	(6)
LDOU	1,458**	1,900**	1,207*	758.0*	296.7	461.3*
	(504.4)	(649.0)	(572.1)	(370.6)	(164.0)	(208.5)
$LDOU^2$	-390.0**	-508.2**	-320.0**	-229.5**	-90.96*	-138.5**
	(123.1)	(160.3)	(128.3)	(95.06)	(42.65)	(52.93)
$LDOU^3$	35.21***	45.78***	28.67**	20.97**	8.585**	12.39**
	(9.615)	(12.70)	(9.183)	(7.868)	(3.635)	(4.281)
URBAN		-560.1***	-1,955***	1,922***	798.0***	1,124***
		(143.1)	(238.1)	(272.5)	(115.9)	(181.0)
LGDPPC			525.9***	85.33	-54.59	139.9**
			(58.20)	(92.84)	(54.17)	(43.63)
RTO				-107.5**	-42.63	-64.84***
				(34.53)	(24.07)	(15.93)
Constant	-1,616**	-1,886**	-5,827***	-2,318**	-25.51	-2,293***
	(643.3)	(797.7)	(783.4)	(782.4)	(438.3)	(432.5)
F-Stat	349.19	244.48	1353.32	1250.96	1828.09	746.26
P-value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Note: In all FE-DKSE models, ENTREP serves as the dependent variable. The robust standard errors are displayed in parentheses.
The number of '***' shows the significance level, with '***' representing 1%, '**' denoting 5%, and '*' indicating 10%.

Table 5b evaluates the impact of DFI on entrepreneurship through depth of usage (DOU). Columns 1 to 4 represent the overall self-employed, and in column 1, the coefficient of LDOU is positive (1458) and the coefficient of $LDOU^2$ is negative (-390.0). These coefficients are statistically significant at 5%, and the coefficient of $LDOU^3$ is positive (35.21). In column 2, the coefficient of URBAN is negative (-560.1). These coefficients are statistically significant at 1%. In column 3, the coefficient of LGDPPC is positive, which is (525.9) significant at 1%. In column 4, the coefficient of RTO is negative (-107.5) significant at 5%. While columns 5 and 6 show the rural self-employed and urban self-employed, respectively. Both columns exhibit both positive and negative values that are statistically significant, but in column 5, the coefficients of LDOU, LGDPPC, and RTO are insignificant. The positive coefficient suggests that an increase in DFI is associated with a corresponding increase in entrepreneurship in China, while the negative value suggests that an increase in DFI is associated with a corresponding decrease in entrepreneurship in China.

Table 5c: Digital financial inclusion and entrepreneurship (DOD) (FE-DKSE).

Variable	Overall				Rural	Urban
	(1)	(2)	(3)	(4)	(5)	(6)
LDOD	1,629	1,508	855.5	1,407	371.7	1,036*
	(1,119)	(1,108)	(697.4)	(806.3)	(294.6)	(514.5)
$LDOD^2$	-435.6	-414.3	-244.6	-378.1	-105.0	-273.0*
	(288.0)	(289.8)	(180.3)	(208.6)	(75.39)	(133.7)
$LDOD^3$	37.47	36.33	21.64	32.45*	9.334	23.11*
	(23.54)	(23.99)	(14.86)	(17.22)	(6.206)	(11.05)
URBAN		-134.9	-2,099***	-2,567***	-1,069***	-1,497***
		(84.09)	(230.5)	(132.2)	(59.36)	(90.29)
LGDPPC			666.9***	638.6***	255.6***	383.0***
			(64.68)	(60.58)	(22.46)	(38.68)
RTO				275.5***	96.69***	178.9***
				(46.56)	(27.16)	(23.76)
Constant	-1,667	-1,384	-6,529***	-6,837***	-2,466***	-4,370***
	(1,368)	(1,291)	(553.6)	(527.4)	(207.7)	(332.0)
F-Stat	45.55	93.03	2099.31	635.17	573.46	275.45
P-value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Note: In all FE-DKSE models, ENTREP serves as the dependent variable. The robust standard errors are displayed in parentheses.
The number of '***' shows the significance level, with '***' representing 1%, and '*' indicating 10%.

Table 5c evaluates the impact of DFI on entrepreneurship through degree of digitalization (DOD). Columns 1 to 4 represent the overall self-employed, and in column 1, the coefficient of LDOD is positive (1629), the coefficient of $LDOD^2$ is negative (-435.6), and the coefficient of $LDOD^3$ is positive (37.47). In column 2, the coefficient of URBAN is negative (-13.49). But these coefficients are statistically insignificant for both values in columns 1 and 2. In column 3 the coefficient of LGDPPC is positive, which is (666.9). In column 4, the coefficient of RTO is positive (275.5). In columns 3, and 4 the values of URBAN, LGDPPC and RTO are significant at 1%. While the columns 5 and 6 show the rural self-employed and urban self-employed, respectively. Both columns exhibit both positive and negative values. Some are statistically insignificant, like values of LDOD

in all columns, which are insignificant except column 6. In column 6, the values of LDOD, $LDOD^2$ and $LDOD^3$ are significant at 10%. The positive coefficient suggests that an increase in DFI is associated with a corresponding increase in entrepreneurship in China, while the negative value suggests that an increase in DFI is associated with a corresponding decrease in entrepreneurship in China. We further estimate impact of DFI on the entrepreneurship across China's different regions, which are classified as Eastern, Central and Western, using Dirscoll-kraay, detailed information regarding results is available upon request.

6 | CONCLUSIONS AND POLICY IMPLICATIONS

This study investigated the impact of DFI on the entrepreneurship in China and across its regions (i.e., rural, urban). This study took data from 2011 to 2019 and focused on China's 30 provinces. In this research, we utilized a comprehensive measure of DFI, which is provided by Peking University. This comprehensive measured is based on three components: the coverage breadth of DFI, the depth of usage of DFI, and the degree of digitalization of DFI. To achieve the study's objective, a fixed-effect Driscoll-Kraay standard error technique is utilized. Furthermore, to confirm the robustness of the findings, the analysis utilized FGLS model. The DSKE model was used to handle the problems of heteroscedasticity and cross-sectional dependency. By employing these advanced statistical techniques, the study aimed to validate and strengthen the results. The results showed that there is a positive and significant relationship between the DFI and entrepreneurship. In this study, we included other control variables, which are economic growth, urbanization and trade openness. Economic growth and trade openness have a positive and significant impact on entrepreneurship, while there is a negative relationship between urbanization and entrepreneurship. Overall findings indicated that there is an N-shaped relationship between the DFI and entrepreneurship. Represent a nonlinear relationship between them. This study is subject to some limitations. We limited the availability of DFI data to period from 2011 to 2019. The findings are specific to China and may not be applicable to other countries.

To boost the use of digital financial services, especially in remote areas, the government should work on improving the internet and network infrastructure. The government should also offer tangible support, like guarantees, to motivate people to embrace digital financial services. These actions aim to broaden the reach of the digital economy, foster entrepreneurship, and, in the long run, motivate regional integration. The government needs to actively expedite the growth of DFI and establish a favorable external environment for entrepreneurship. To enhance the attainment of entrepreneurial targets, it is essential to adapt DFI policies according to regional. The government must strengthen regulations to ensure the security and privacy of digital transactions, building confidence among entrepreneurs. It should facilitate international trade by aligning digital financial inclusion policies with trade openness initiatives, simplifying cross-border transactions.

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All authors contributed equally to the conception and design of the study. All authors have read and agreed to the published version of the manuscript.

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