

DIGITAL FINANCE AND RURAL ENTREPRENEURSHIP: MECHANISMS AND EFFECTS—EVIDENCE FROM 1,846 COUNTIES

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Abstract

Rural entrepreneurship serves as a key driver for promoting high-quality development of rural industries and advancing comprehensive rural revitalization. Characterized by inclusivity, accessibility, low cost, and low barriers, digital finance addresses the limitations of traditional financial services in rural areas, providing enhanced financial support for entrepreneurial activities among returnees such as migrant workers, skilled individuals, university graduates, and entrepreneurs. Based on panel data from 1,846 county-level units in China spanning 2014–2022, this paper analyzes the impact of digital finance development on rural entrepreneurship. Empirical results demonstrate that: 1. Digital finance significantly promotes rural entrepreneurship through three mechanisms: enhancing agricultural mechanization and facilitating rural industrial upgrading. Human capital positively moderates this promotive effect. 2. Digital finance exhibits a significant positive impact on rural entrepreneurship in eastern and central regions, but an insignificant effect in western regions. 3. In-depth analysis of the mechanisms and effects through which digital finance fosters rural entrepreneurship can accelerate comprehensive rural revitalization, contribute to building China into an agricultural powerhouse, and provide robust support for advancing agricultural and rural modernization.

Keywords: Digital finance; Rural Entrepreneurship; Agricultural Mechanization; Industrial Upgrading; Human capital

INTRODUCTION

Rural entrepreneurship plays a key role in advancing the high-quality development of rural industries and driving comprehensive rural revitalization. Since 2015, China has rolled out a series of major policy documents encouraging migrant workers, skilled individuals, university graduates, and entrepreneurs to return to their hometowns and engage in innovative business activities. The entrepreneurial initiatives of these returnees have significantly accelerated the growth of new types of agricultural business entities, such as farmers' cooperatives, family farms, and leading agricultural enterprises. These developments have effectively expanded employment opportunities for rural residents and are crucial for facilitating agricultural transformation and upgrading, building complete agricultural value chains, and promoting the high-quality development of rural industries (Ruan et al., 2023; Zhao & Lin, 2024).

Rural entrepreneurship has seen notable progress in recent years. First, the number of entrepreneurs has continued to grow. By the end of 2022, the total number of people returning to or entering rural areas for entrepreneurship had reached 12.2 million. Second, the entrepreneurial landscape has become more diverse. Entrepreneurial entities now include not only new types of agricultural business operators such as family farms, specialized farmer cooperatives, and agricultural socialized service organizations, but also returnees including migrant workers, university graduates, demobilized soldiers, and entrepreneurs. As of October 2023, nearly 4 million family farms, 2.216 million farmer cooperatives, over 90,000 leading agricultural enterprises at or above the county level, and 1.07 million agricultural socialized service organizations had been

established. Third, the forms of entrepreneurial activity have become more varied. More than 80% of rural start-ups are integrated projects combining the primary, secondary, and tertiary industries, mainly involving agriculture-related fisheries, agricultural product processing, and rural leisure tourism.

Despite this rapid development, rural entrepreneurship still faces several challenges. For instance, most entrepreneurial projects are agricultural in nature, characterized by small scale, long cycles, and high risk. Entrepreneurs themselves often have relatively low levels of formal education, lack collateral, and maintain incomplete financial records. As a result, rural entrepreneurs frequently struggle to access credit from formal financial institutions, and they commonly face difficulties in obtaining affordable financing (He & Liu, 2019; Yang et al., 2013; Xie et al., 2018). On the supply side, the financial ecosystem in rural areas remains underdeveloped, with limited financial services available. Financial institutions lack sufficient incentives to fund high-risk entrepreneurial activities in such settings (Wen & Chen, 2020).

At the end of October 2023, the Central Financial Work Conference emphasized the need to accelerate the development of a financial powerhouse, focusing on five major areas including digital finance and inclusive finance to promote high-quality financial development. Digital finance represents the integration of digital technologies with the financial industry. By leveraging data elements and digital technologies, it drives and expands inclusive finance, thereby improving efficiency, reducing costs, and enhancing customer experience. Digital finance relies on technologies such as artificial intelligence, cloud computing, big data, and blockchain, and integrates with various scenarios including e-commerce, social media, and short-video platforms. The online model overcomes the reliance of traditional finance on physical branches and lowers transaction costs (Lu & Zhuang, 2022). Big-data credit scoring based on e-commerce, social media, and short-video platforms lowers the threshold for accessing financial services, enabling coverage of long-tail customers, rural areas, and small and micro enterprises, thus providing financial support for rural entrepreneurial activities (Chen & Yang, 2017; Huang et al., 2023).

Most studies indicate that digital finance promotes entrepreneurship (Xie et al., 2018; Tao et al., 2021). Digital finance facilitates entrepreneurial activity by easing financing constraints for small and medium-sized enterprises (Aghion et al., 2007; Qian et al., 2020), promoting industrial transformation and upgrading (Nie et al., 2021; Li & Liu, 2021), enhancing technological innovation (Chen & Yang, 2021), and increasing social trust (He & Li, 2019). However, some studies point out that the digital divide and knowledge divide can prevent rural households with low financial literacy and limited capabilities from accessing digital financial services in a timely manner, thereby weakening the impact of digital finance on rural entrepreneurship (Zhang & Yin, 2016). Tao et al. (2021) find that the effect of digital finance on regional entrepreneurship has a threshold pattern, exhibiting a non-linear relationship that grows over time. In terms of research subjects, the existing literature focuses primarily on entrepreneurship among small and micro enterprises (Xie et al., 2018; Yang et al., 2022), urban entrepreneurship (Li & Shi, 2024; Lu et al., 2022), farmer entrepreneurship (He & Li, 2019), and household entrepreneurship (Zhang & Sheng, 2021; Yin et al., 2019). This paper uses panel data from 1,846 county-level units in China to analyze the impact of digital finance development on rural entrepreneurship from 2014 to 2022. It further examines the mediating roles of agricultural mechanization level, financing constraints, and industrial structure upgrading, as well as the moderating role of human capital level.

This paper offers three potential marginal contributions. First, regarding the measurement of entrepreneurial activity, existing studies have largely used indicators such as whether an individual starts a business (Li et al., 2017; Cheng & Luo, 2009; Dong et al., 2019), the number of newly registered entrepreneurial firms (Jiang et al., 2013; Zhu & Kong, 2018; Xie et al., 2018), entrepreneurial performance (measured as the ratio of annual entrepreneurial revenue to total cost) (Guo & He, 2017; Huang et al., 2010; He & Li, 2019), or entrepreneurial vitality (the share of self-employed and private enterprise workers in total employment) (Li & Li, 2017; Feng & Cai, 2021). However, given the unique characteristics of rural entrepreneurship, these indicators do not fully

capture the overall picture and thus cannot accurately reflect the actual situation. To address this, this paper adopts the county-level rural entrepreneurship index for China released by the CATER-Qiyao Rural Industry Research Team. This index is constructed using a comprehensive subjective-objective weighting method and measures rural entrepreneurship at the county, prefecture-level city, and provincial (municipality) levels. It has strong representativeness and high accuracy, allowing for a more complete and realistic depiction of the process and current state of rural entrepreneurship across Chinese counties.

Second, in terms of the unit of analysis, most existing studies have examined the relationship between digital finance and rural entrepreneurship at the provincial level (Li & Liu, 2021; Huang & Yin, 2023; Feng, 2024; Xie et al., 2018) or the prefecture-level city level (Huang et al., 2021). However, aggregated provincial- or city-level averages cannot truly reflect the actual rural entrepreneurship conditions in most counties. This paper addresses this gap by using a sample of 1,846 Chinese counties to study the relationship between digital finance and rural entrepreneurship, thereby providing more contextually relevant county-level evidence.

Third, with respect to the mechanisms of influence, the existing literature suggests that digital finance promotes entrepreneurship mainly by easing financing constraints and facilitating industrial structure upgrading. This paper carefully analyzes the characteristics of rural entrepreneurship and finds that digital finance can also promote rural entrepreneurship by enhancing agricultural mechanization. By extending inclusive finance through digital technologies, digital finance increases the accessibility of capital inputs in the agricultural sector, effectively raising the level of agricultural mechanization. This, in turn, drives the scaling, intensification, and industrialization of agricultural production, reduces production costs, increases the value-added of agricultural products, and attracts more rural entrepreneurs to enter the agricultural sector. This finding offers a new perspective on how digital finance promotes rural entrepreneurship—specifically, that digital inclusive finance can boost agricultural mechanization and thereby foster rural entrepreneurship, thereby enriching and expanding the understanding of the mechanisms linking digital finance to rural entrepreneurship.

LITERATURE REVIEW AND HYPOTHESIS FORMULATION

Direct Impact of Digital Finance on Rural Entrepreneurship

Digital finance expands financial services through the in-depth application of data elements and digital technologies. With the dual attributes of digital and finance, it accelerates the free flow and efficient allocation of capital, information, data, and other factors. The boundaries of finance are continuously extended through data, technology, and scenarios, making the financial system more inclusive (Qian et al., 2020). By leveraging digital technologies such as big data, artificial intelligence, cloud computing, and blockchain, digital finance can reduce the cost of financial services, mitigate information asymmetry, improve the efficiency of financial service delivery, enhance financial inclusiveness, and strengthen financial risk control capabilities. In this way, it promotes rural entrepreneurship and the high-quality development of rural industries.

First, the low cost, wide coverage, convenience, and sharing characteristics of digital finance give it a natural advantage in promoting rural entrepreneurship. Digital finance replaces physical bank branches and manual services with mobile banking and third-party payments, significantly reducing the operating and customer acquisition costs of financial services (Guo et al., 2020; He & Liu, 2021; Zhang et al., 2021). Compared with traditional finance, digital finance places greater emphasis on economies of scale and the long-tail effect, shifting the focus of financial services down to rural areas and remote mountain regions. With just a smartphone, rural households and rural entrepreneurs can conveniently conduct most financial transactions, improving both the efficiency of financial transactions and user experience (Li, 2015; Guo et al., 2020). Digital finance is a key driver of business model transformation (Jiang & Luo, 2019). It changes the face-to-face transaction model of traditional business, enabling online transactions that are not constrained by time or

location, thereby effectively reducing the importance of geographic distance and economic distance in financial services (Lu, 2018; Zhang & Xing, 2021). The rise of various platforms such as social media, e-commerce, and live streaming, together with the rapid development of logistics, allows rural households to sell their agricultural products nationwide, thereby facing larger markets and providing broader space for rural entrepreneurship.

Second, the digital credit model based on "data" is less costly and more efficient than the traditional credit model based on "collateral," lowering the threshold for credit services and enhancing financial inclusiveness. Digital finance integrates capital, technology, and various scenarios. Platform firms accumulate large amounts of data through these scenarios, and big data technology enables them to assess risks, identify fraudulent behavior, and discover high-quality customers from massive data at very low cost. This improves decision-making efficiency and risk control, effectively alleviates information asymmetry, reduces reliance on collateral, and provides more credit opportunities for long-tail customers such as farmers, entrepreneurs, and small and micro enterprises (Zhang, 2021). Risk is a major challenge in entrepreneurship, yet rural entrepreneurs often lack effective risk identification and mitigation capabilities. Digital finance can offer more targeted, convenient, and rapid financing services, as well as more diverse, intelligent, and personalized risk management services for rural returnees starting businesses. It can help rural entrepreneurs improve their financial literacy, enhance their ability to integrate production factors, strengthen management skills, and reduce operational risks, thereby boosting entrepreneurial confidence and success rates (Tang et al., 2020).

Third, the deep integration of finance, data, and scenarios has given rise to new forms of finance such as social finance and e-commerce finance. This integration improves the efficiency and methods of information dissemination in rural areas and reduces the costs of information search, evaluation, tracking, and user matching for rural entrepreneurs (Goldfarb & Tucker, 2019; Zhou et al., 2023). It also helps break the "information island" problem in the entrepreneurial process (Beck et al., 2018; Tang et al., 2022). Information is a crucial resource for entrepreneurship, but rural entrepreneurs often lack effective channels and means to access information, facing "information constraints." Through platforms such as social media, e-commerce, and live streaming, ordinary rural households and returnee entrepreneurs can obtain richer and more accurate information on markets, policies, technology, and other areas in a timely manner. This enables them to better grasp market opportunities and industry trends, leading to better entrepreneurial opportunities and stronger entrepreneurial intentions. With the support of these platforms, rural entrepreneurs have access to more channels and more diverse forms of entrepreneurship. The inclusiveness of digital finance equalizes entrepreneurial opportunities and improves the entrepreneurial behavior of rural households (Zhang et al., 2019; Feng & Zhang, 2024). Whether an individual succeeds in entrepreneurship depends largely on the opportunity factors available to them (Shi et al., 2022). The deep integration of data, finance, and scenarios provides rural households with fairer development opportunities and promotes rural entrepreneurship. Based on the above analysis, this paper proposes Hypothesis 1.

H1: The development of digital finance can promote rural entrepreneurship.

Indirect Impact of Digital Finance on Rural Entrepreneurship

1. Digital finance promotes rural entrepreneurship by raising the level of agricultural mechanization.

Agricultural mechanization refers to the extensive use of machinery in agricultural production to replace human labor and animal power, thereby improving production efficiency, reducing labor intensity, and enhancing the quality and yield of agricultural products. Agricultural mechanization is a prerequisite for agricultural and rural modernization. Without agricultural mechanization, there can be no modernization of agriculture and rural areas—this is an established rule of development. At present, agricultural production in China has entered a stage dominated by mechanized operations. However, the high costs of purchasing and maintaining agricultural

machinery impede the process of agricultural mechanization (Kuang & Lu, 2017). Clearly, the further promotion of agricultural mechanization requires financial support.

First, digital finance integrates multidimensional data—including satellite remote sensing data, industrial chain data, and government data—through digital technologies such as big data and the Internet of Things (IoT). It collects, screens, processes, aggregates, and models these data to construct big data profiles for agricultural machinery (Ren et al., 2019). This enables credit assessment and risk monitoring for agricultural machinery loans. By issuing unsecured agricultural machinery loans based on data assets, digital finance can alleviate information asymmetry, solve the collateral problem in machinery lending (Diniz et al., 2012; Mushtaq et al., 2019), improve the quality and efficiency of loan provision, and address the financing pain points in agricultural mechanization. Second, digital finance enables remote monitoring and intelligent management of agricultural machinery through deep mining and analysis of agricultural big data. This increases the utilization rate and operational efficiency of machinery and accelerates the transition of smart agricultural machinery from laboratories to farmlands. The structure of agricultural technology and equipment is continuously being adjusted, transformed, and upgraded. Large-scale, intelligent, and smart agricultural technology and equipment are constantly emerging, providing the hardware foundation for improving agricultural mechanization (Zhong et al., 2018; Hou, 2008).

The development of agricultural mechanization gives rise to entrepreneurial opportunities in agricultural machinery socialized services, such as machinery rental, leasing, and trusteeship. Rural entrepreneurs can establish machinery rental, sharing, and trusteeship platforms that integrate idle machinery and provide machinery rental services, app-based reservation services (similar to ride-hailing), and full-process mechanized trusteeship services covering plowing, sowing, management, harvesting, and marketing (Zhou & Kong, 2019). Second, agricultural mechanization creates opportunities for entrepreneurship in smart agriculture and machinery-related supporting industries. Agricultural mechanization enables smart agriculture entrepreneurship through the application of big data, artificial intelligence, IoT, satellite remote sensing, and other technologies, launching projects such as drone plant protection, autonomous machinery trusteeship, and smart farms, thus creating an ecosystem of "new agri-workers + new business forms + new income." At the same time, agricultural mechanization drives entrepreneurship in machinery supporting industries, such as the promotion of smart agricultural machinery, machinery repair and parts supply chains, and the development and adaptation of smart machinery, thereby empowering rural entrepreneurship. Based on this analysis, this paper proposes Hypothesis 2.

H2: Digital finance can promote rural entrepreneurship by improving the level of agricultural mechanization.

2. Digital Finance Promotes Rural Entrepreneurship by Promoting Industrial Upgrading

Rural industrial upgrading is an important dimension of the high-quality development of rural industries and a key engine for promoting comprehensive rural revitalization (Sun & Xu, 2021). Rural industrial upgrading refers to extending agriculture into the secondary and tertiary industries, continuously lengthening the industrial chain, expanding industrial functions, and promoting industrial integration. By leveraging the characteristic resources of agriculture and rural areas, it aims to develop multiple functions of agriculture, explore the diverse value of rural areas, and transform rural resource advantages, ecological advantages, and cultural advantages into product advantages and industrial advantages. This enhances market competitiveness and risk resistance capacity, thereby promoting the high-quality development of rural industries. Vertically, it extends the industrial chain by integrating production, processing, and sales, expanding from production to deep processing, warehousing and preservation, cold-chain logistics, and branding and marketing. Horizontally, it expands industrial functions by integrating agriculture, culture, and tourism, developing new business forms such as educational farms, research bases, and local cultural experience tours. Currently, rural industrial development still faces many challenges, including

small scale, scattered 布局, short chains, and low levels of product variety, quality, and branding. The quality, efficiency, and competitiveness of agriculture remain weak, and natural and market risks are high. As a result, financial institutions are generally unwilling to provide financial support for rural industries (Ge et al., 2022), hindering the process of rural industrial upgrading.

Digital finance is embedded in agricultural production, transportation, marketing, finance, and other links, and continuously integrates into the entire agricultural production process (Tian & Li, 2022). By enabling technological supply, digital finance promotes innovation and upgrading of the agricultural industrial chain. It improves the resilience of the supply chain through better logistics matching, increases the value-added of the value chain by reducing agricultural product transaction costs, and enhances the structure of the capital chain by easing credit rationing. This creates a complete modern agricultural industrial chain encompassing "planting/breeding – transportation – processing – packaging – sales – logistics distribution," thereby upgrading the industrial structure and promoting the integration of the three industries.

Rural industrial upgrading provides numerous entrepreneurial opportunities in two ways: extending the industrial chain and expanding industrial functions. Vertically, extending the industrial chain integrates production, processing, and sales. For example, deep processing, e-commerce sales, warehousing and logistics, and brand building all offer abundant entrepreneurial opportunities for rural households. Leveraging local rural characteristics, entrepreneurs can develop specialty agricultural product processing, central kitchens, on-site storage, pre-cooling and preservation, grading and packaging, cold-chain logistics, urban distribution, and e-commerce platform operations. This creates a full-chain entrepreneurial ecosystem of "production + processing + distribution + branding," allowing the value added from processing, services, and branding to remain in rural areas and generating higher profit margins for rural entrepreneurship. Horizontally, expanding industrial functions cultivates new rural industries and business forms. The development of emerging rural industries is attracting migrant populations to return to their hometowns, either to join leading enterprises or to start their own businesses based on their own land. Farmer entrepreneurship has moved beyond the traditional agricultural scope, expanding into new areas combining agriculture with modern service sectors such as leisure, culture and tourism, health and wellness, and education. This provides a new engine for rural entrepreneurship and high-quality development (Hui & Yang, 2022; Zhao et al., 2017). Based on this analysis, this paper proposes Hypothesis 3.

H3: Digital finance can promote rural entrepreneurship by promoting industrial structure upgrading.

3. Human Capital Level Plays a Moderating Role in Digital Finance Promoting Rural Entrepreneurship

Human capital, consisting of workers' abilities, knowledge, and skills, reflects the quality of the labor force (Yang et al., 2006). Existing studies have shown that human capital directly determines individuals' cognitive abilities and also affects their learning capacity and financial literacy (Agarwal et al., 2015). Digital finance is driven by digital technologies, uses mobile phones and other smart terminals as carriers, and relies on mobile internet to provide financial services to rural households anytime and anywhere (Liu & Luo, 2019; Chen & Ren, 2020). The use of digital technologies requires rural households to have substantial knowledge and operational skills. At the same time, rural entrepreneurship involves multiple stages, from identifying and seizing entrepreneurial opportunities, choosing financing channels, and identifying and avoiding risks, to making sound entrepreneurial decisions. Each stage requires rural households to have a certain level of financial literacy and knowledge. Therefore, human capital is crucial for whether rural households can use digital finance to engage in rural entrepreneurship (Li et al., 2024).

First, digital financial services have a certain knowledge threshold. If rural households have low educational attainment or poor cognitive abilities, they may find it difficult to access the convenient services of digital finance (He et al., 2017; Yin & Zhang, 2018) and may not easily grasp

the entrepreneurial opportunities provided by digital finance. Rural households with lower education levels may have difficulty understanding the nature and operating processes of digital financial products, which can further create a sense of distance and fear toward these products and services. As a result, they may lack confidence, hesitate to use, or be unable to use digital finance (Xiang & Wu, 2024), making it difficult for them to engage in rural entrepreneurial activities (Yang et al., 2024; Dong et al., 2019). In contrast, rural households with higher education levels can obtain richer and more accurate market information, technical information, and other types of information in a timely manner. They are better able to grasp market opportunities and industry trends, which provides more opportunities for rural entrepreneurship (Ma & Yang, 2023).

Second, rural households with insufficient knowledge or weak cognitive abilities may face significant risks when using digital financial services, and may even encounter financial fraud (Xiang & Wu, 2024). By contrast, rural households with higher education levels can more effectively use digital financial tools to avoid entrepreneurial risks. They can use digital finance platforms to understand market dynamics and price fluctuations, use financial products such as futures and insurance to hedge against risks from agricultural product price volatility, and have a relatively stronger ability to evaluate entrepreneurial projects (Zhou, 2015), thereby facilitating rural entrepreneurial activities. Based on this analysis, this paper proposes Hypothesis 4.

H4: The level of human capital plays a positive moderating role in digital finance promoting rural entrepreneurship.

In summary, the theoretical mechanism through which digital finance affects rural entrepreneurship is illustrated in Figure 1.

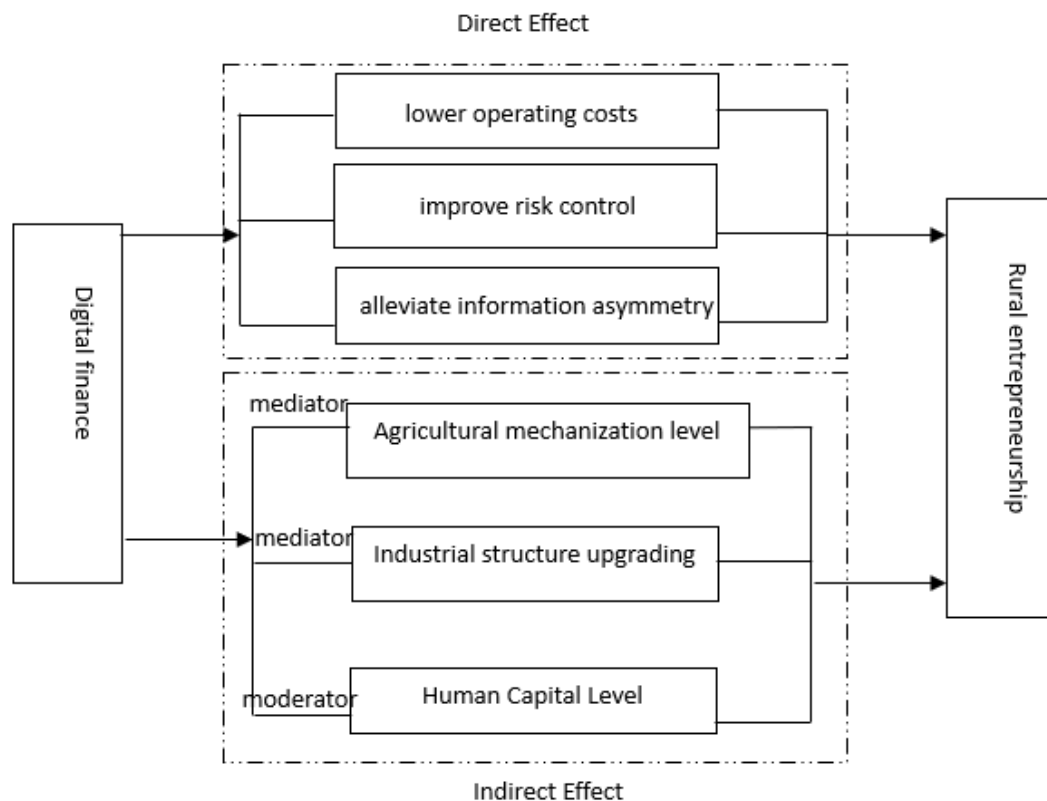


Figure 1. Theoretical mechanism of digital finance affecting rural entrepreneurship

EMPIRICAL MODEL SPECIFICATION

1. Model and Variables

This paper uses panel data from 1,846 Chinese counties spanning 2014 to 2022 to empirically examine the impact of digital finance development on rural entrepreneurship. To this end, we construct the following two way fixed effects model:

$$REp02_{it} = \alpha_0 + \alpha_1 index02_{it} + \alpha_c Controls_{it} + \mu_i + \lambda_t + \varepsilon_{it} \dots \dots \dots (1)$$

where i^* indexes counties and t^* indexes years. $REp02_{it}$ is the dependent variable, the rural entrepreneurship index, representing the level of rural entrepreneurship in county i^* in year t^* . $index02_{it}$ is the core independent variable, the aggregate digital finance index. $Controls_{it}$ is a set of control variables that may influence rural entrepreneurship. μ_i represents time invariant regional fixed effects. λ_t denotes year fixed effects that do not vary across individuals. ε_{it} is the random error term. α_0 is the intercept term; α_1 is the regression coefficient of the core independent variable; and α_c are the coefficients for the control variables.

In mediation analysis, the relationship between the dependent and independent variables may be merely correlational rather than causal. Moreover, potential endogeneity issues may render the estimation results unreliable. Therefore, following Jiang (2022), this paper uses the following model for mechanism testing:

$$M_{it} = \gamma_0 + \gamma_1 index02_{it} + \gamma_c Controls_{it} + \mu_i + \lambda_t + \varepsilon_{it} \dots \dots \dots (2)$$

In Model (2), M_{it} is the dependent variable, including the level of agricultural mechanization and industrial structure upgrading, and $index02_{it}$ represents the county-level digital finance development index. All other variables remain the same as in Model (1).

2. Variable Selection and Definition

Dependent Variable

This variable measures the level of rural entrepreneurship development at the county level. This paper uses the China Rural Innovation and Entrepreneurship Index, constructed by the CATER-Qiyan Rural Industry Research Team, to measure county-level rural entrepreneurship development (the original index is log-transformed). This index comprises two primary indicators, seven secondary indicators, and 21 tertiary indicators, providing a reasonably objective and accurate measure of innovation and entrepreneurship activities at the Chinese county level (Ruan et al., 2024).

Core Independent Variable

This variable captures the level of digital inclusive finance development at the county level. This paper uses the Peking University Digital Financial Inclusion Index, released by the Digital Finance Research Center of Peking University, to measure county-level digital inclusive finance development (the original index is log-transformed). This index covers three dimensions—breadth of coverage, depth of use, and degree of digitization—with 24 indicators, offering a comprehensive and complete measurement of digital finance development (Guo et al., 2020).

Control Variables

Following the approaches of Qian et al. (2020), Xie et al. (2018), and Li and Liu (2021), this study selects the following control variables: economic growth level (Ingdp), infrastructure level (infrastructure), fiscal autonomy (fiscal), urbanization level (urban), marketization level (market), and science and education expenditure level (science and education). Table 1 presents the variable definitions and measurement methods used in this paper.

Table 1. Variable Definitions and Measurement Methods

Variable type	Variable Symbol	Variable name	Variable Definition
explained variable	REp02	China Rural Entrepreneurship Index	Logarithm of the China Rural Entrepreneurship Index
core independent variable	index02	Peking University Digital Financial Inclusion Index	Logarithm of the Peking University Digital Financial Inclusion Index
	Ingdp	Economic growth level	Logarithm of real GDP per capita
	infrastructure	Infrastructure level	Total fixed asset investment in the whole society / regional GDP
	market	Marketization level	《China Marketization Index》
control variable	fiscal	Fiscal autonomy	Local general budget expenditure / local general budget revenue
	Science and education	Science and education expenditure level	Science and education expenditure / general government expenditure
	urban	Urbanization level	Urban permanent population / total permanent population
mediating variable	mechanization	Agricultural mechanization rate	Mechanized harvesting area (hectares) / (administrative land area (km ²) × 100)
	Industrial upgrading	Industrial structure upgrading	Value added of tertiary industry / value added of secondary industry
moderating variable	capital	Human capital level	(Number of students in regular primary schools + regular secondary schools + secondary vocational schools) / (total year-end population × 100)

3. Data Sources

The data for this paper come mainly from the China Digital Financial Inclusion Index jointly compiled by the Digital Finance Research Center of Peking University and Ant Group. The second source is the China Rural Entrepreneurship Index constructed by the CATER-Qiyan Rural Industry Research Team. The remaining indicators are obtained from the China County Statistical Yearbook.

This paper uses panel data from 1,846 counties across 28 provinces (autonomous regions) in China from 2014 to 2022 as the research sample for empirical analysis. Missing values are filled by consulting local statistical bulletins and using linear interpolation. Descriptive statistics of the variables are shown in Table 2.

Table 2. Descriptive Statistics of Variables

Variable	Mean	Std. Dev.	Min	Max
Rural entrepreneurship	2.4107	0.5072	-6.8124	3.9409
Digital finance	4.5107	0.3293	2.3263	4.9528
Economic growth level	10.4758	0.6517	8.4007	13.4558
Infrastructure level	1.1011	0.6747	0.0448	3.9198
Marketization level	13.0143	1.4460	9.6724	16.1792
Fiscal autonomy	6.7656	7.3960	0.9812	45.7049
Science and education expenditure level	0.1911	0.0385	0.0475	0.3340
Urbanization level	0.5489	0.1140	0.2983	0.8425

EMPIRICAL RESULT AND ANALYSIS

Benchmark Regression Result

The baseline model used in this empirical analysis is a two-way fixed effects model. Column (1) of Table 3 includes only the digital finance variable, while columns (2) and (3) progressively add control variables and both region and year fixed effects. The results show that the coefficient of the digital finance index is positive and significant at the 1% level, indicating that the development of digital finance has a notable promoting effect on rural entrepreneurship.

This suggests that digital finance, driven by big data and other digital technologies and delivered through mobile terminals, shifts the focus of financial services toward rural areas (Li, 2015; Guo et al., 2020). Rural entrepreneurs can conduct most financial transactions via mobile banking without visiting bank branches. The purely online model substantially reduces both operating and customer acquisition costs (Guo et al., 2020; He & Liu, 2021), allowing rural entrepreneurs to access inclusive financial services. This improves the coverage, availability, and quality of rural financial services (Qi & Li, 2019) and helps bridge the last mile of financial access. On the one hand, returnees and entrepreneurs use e-commerce platforms to sell agricultural products from villages to cities. On the other hand, they leverage short-video and social media platforms to promote rural tourism and bring tourists from cities to villages. These developments enable rural entrepreneurs to scale up production and expand their e-commerce operations. Thus, Hypothesis 1 is supported.

Table 3. Baseline regression results

Variable	(1) REp02	(2) REp02	(3) REp02
index02	0.181*** (0.0114)	0.0607*** (0.0175)	0.107*** (0.0225)
Economic growth level		0.0783*** (0.00756)	0.0484*** (0.0118)
Infrastructure level		0.0620*** (0.00623)	0.00658 (0.00828)
Marketization level		0.00339 (0.00381)	-0.0337* (0.0205)
Fiscal autonomy		-0.00125 (0.000931)	-0.00399*** (0.00117)
Science and education expenditure level		-1.463*** (0.101)	0.524*** (0.141)
Urbanization level		0.204*** (0.0396)	-0.188*** (0.0673)
Region fixed effects	NO	NO	YES
Time fixed effects	NO	NO	YES
_cons	1.607*** (0.0516)	1.408*** (0.0780)	1.910*** (0.299)
N	16065	12636	12619
R ²	0.015	0.056	0.701

Endogeneity Test

To address potential endogeneity issues such as omitted variable bias and reverse causality, this study adopts two instrumental variables (IVs) following Bartik (2009) and Huang et al. (2019). The two-stage least squares (IV-2SLS) method is applied to re-estimate Equation (1). The results are reported in Table 4. The first instrument (lv1) is a Bartik-type instrument, constructed as the product of the one-year lag of the digital financial inclusion index and its first difference. This instrument is directly correlated with the current level of digital finance in a county but does not

affect rural entrepreneurship through other channels, thus satisfying both the relevance and exogeneity conditions for a valid instrument.

The second instrument (lv2) is the number of post offices per city at the end of 1984, interacted with the one-year lag of the digital financial inclusion index. On the one hand, the number and distribution of post offices historically influence local residents' internet usage skills and habits, reflecting the underlying conditions for information technology development. This is closely related to changes in digital finance. On the other hand, after controlling for variables related to rural entrepreneurship, the number of post offices at the end of 1984 has no direct pathway to influence rural entrepreneurship. Therefore, this historical postal variable serves as a suitable instrument for digital finance.

As shown in Table 4, the Kleibergen-Paap rk LM statistic (for under-identification) has a p-value of 0.000 in all cases, strongly rejecting the null hypothesis that the instruments are under-identified. For the weak identification test, the Cragg-Donald Wald F statistic exceeds the Stock-Yogo critical value at the 10% significance level, indicating that the chosen instruments are valid. After employing both instrumental variables in the two-stage least squares estimation, the estimated coefficient of the digital finance index (index02) remains significantly positive. These results further reinforce the main findings of this study.

Table 4. Endogeneity Test Regression Results

Variable	(1) lv1		(2) lv2	
	first REp02	second REp02	first REp02	second REp02
Index02		0.158 ** (0.042)		0.242* (0.143)
lv1	1.315 *** (0.020)			
lv2			0.003*** (0.000)	
Control variable	YES	YES	YES	YES
Region fixed effects	YES	YES	YES	YES
Time fixed effects	YES	YES	YES	YES
Kleibergen-Paap rk LM		281.880***		112.24***
Cragg-Donald Wald F		5030.345		133.620
N	12484	12484	12484	12484
R ²	0.937	0.097	0.878	0.049

Robustness Tests

This study conducts the following robustness checks.

First, we adjust the sample period. Considering that the COVID-19 outbreak at the end of 2019 may have affected the regression results and caused estimation bias, we exclude the data from 2020 to 2022 and re-run the regressions. As shown in column (1) of Table 5, the results are largely consistent with the baseline findings.

Second, we perform regressions after winsorizing the data. The main explanatory variables are winsorized at the 1% level, and the panel fixed effects model is re-estimated. The results are presented in column (2) of Table 5. The estimated coefficients and significance levels of the key explanatory variables do not change substantially.

Third, we add additional control variables. Following Lin et al. (2023), we include foreign investment level, degree of openness to trade, fixed-line telephone penetration, market size, and government intervention. The regression results are reported in column (3) of Table 5. The positive effect of digital finance development on rural entrepreneurship remains, and the coefficients are even somewhat larger than those in the baseline regression.

Taken together, these robustness tests yield results that are very similar to those reported earlier. The parameter estimates and significance levels show no notable changes, confirming that the main findings of this study are robust and reliable.

Table 5. Robustness Test Regression Results

Variable	(1) Adjusted sample period REp02	(2) Winsorized REp02	(3) Additional control variables REp02
Index02	0.128*** (0.0280)	0.123*** (0.0319)	0.0960*** (0.0313)
Control variable	YES	YES	YES
Region fixed effects	YES	YES	YES
Time fixed effects	YES	YES	YES
_cons	-1.371*** (0.468)	1.778*** (0.401)	1.988*** (0.485)
N	6984	12636	11661
R ²	0.113	0.097	0.104

Heterogeneity Test

To examine how digital finance affects rural entrepreneurship across different regions of China, we divide the 28 provinces (autonomous regions) in our sample into three broad areas: eastern, central, and western. Separate regression analyses are conducted for each region. Table 6, columns (1), (2), and (3) present the differences in the effect of digital finance on rural entrepreneurship across these regions.

Table 6. Heterogeneity Test Regression Results

Variable	Regional Heterogeneity		
	Eastern region (1)	Central region (2)	Western region (3)
	REp02	REp02	REp02
Index02	0.101* (0.0595)	0.164*** (0.0584)	0.0413 (0.0511)
Control variable	YES	YES	YES
Region fixed effects	YES	YES	YES
Time fixed effects	YES	YES	YES
_cons	1.902** (0.842)	-1.409* (0.729)	2.437*** (0.721)
N	3865	4805	3966
R ²	0.104	0.252	0.066

FURTHER ANALYSIS

Mediation Analysis

First, as shown in Table 7, column (2), the estimated coefficient of digital finance on agricultural mechanization is significantly positive. This indicates that the development of digital finance promotes agricultural mechanization. Digital finance expands the scope of financial services and reduces service costs, providing new agricultural business entities with broader and more

efficient financing channels, thereby injecting capital into agricultural mechanization (Yan et al., 2022). Agricultural mechanization improves production efficiency and reduces production costs, making agricultural operations more profitable. It also facilitates large-scale farming. Some large-scale growers or agricultural cooperatives lease or transfer land to use machinery intensively, fully realizing the substitution effect between machinery and labor. This, in turn, reallocates surplus labor to rural entrepreneurship, thereby promoting rural entrepreneurial activity (Zhang & Wang, 2021). Thus, Hypothesis H2 is supported.

Second, according to Table 7, column (3), the estimated coefficient of digital finance on the upgrading of the county-level industrial structure is significantly positive, indicating that digital finance significantly promotes industrial structure upgrading. Leveraging the unique advantages of digital technologies such as the internet and big data analytics, digital finance embeds financial services into industrial and supply chains. Taking agriculture as the foundation, it extends the industrial chain, integrates production, processing, and sales, and expands into deep processing, warehousing and preservation, cold chain logistics, branding, and marketing. This optimizes the rural industrial structure (Yi & Gu, 2023). The optimization of the industrial structure helps rural entrepreneurs promote factor flows through digital technologies, logistics infrastructure, e-commerce, and financial services, leading to industrial agglomeration. This, in turn, increases entrepreneurial opportunities and reduces entrepreneurial risks (Cui & Jiao, 2024). Hence, Hypothesis H3 is validated.

Table 7. Mediation Analysis Regression Results

Variable	(1) REp02	(2) mechanization	(3) Industrial upgrading
index02	0.107*** (0.0302)	0.0615*** (0.0139)	0.514*** (0.103)
control variable	YES	YES	YES
Region fixed effects	YES	YES	YES
Time fixed effects	YES	YES	YES
_cons	1.910*** (0.484)	0.137 (0.209)	-3.753* (2.240)
<i>N</i>	12619	12258	12619
<i>R</i> ²	0.701	0.904	0.180

Moderation Effect Analysis

In Table 8, the interaction term between digital finance and the level of human capital has a significantly positive estimated coefficient for rural entrepreneurship. This suggests that digital finance has a stronger positive impact on rural entrepreneurship in regions with higher human capital.

In recent years, various rural revitalization policies have created a "policy push," while the development of home regions has generated an "internal pull," accelerating the return of college graduates, skilled individuals, and migrant workers to their hometowns. Many of these returnees engage in rural entrepreneurial activities, injecting human capital into rural areas (Zhong & Kong, 2022). In regions with higher human capital, rural entrepreneurs—particularly migrant workers—have a better understanding, acceptance, and usage of digital finance compared to those in lower-human-capital regions. They are also more inclined to use credit, insurance, and other financial tools to support their entrepreneurial activities. This, to some extent, helps fully unleash the entrepreneurial potential of rural entrepreneurs, attracts external talent to start businesses in rural areas, and encourages vocational schools, agricultural broadcasting schools, research institutes, and university experts to serve agriculture and rural development. As a result, a virtuous cycle of talent and resources is formed, providing a favorable environment and platform for digital finance

to promote rural entrepreneurship (Liu & He, 2022). Therefore, the positive moderating role of human capital is supported, and Hypothesis H4 holds.

Table 8. Moderation Effect Regression Results

Variable	(1) REp02	(2) REp02
index02	0.104*** (0.0310)	0.0935*** (0.0319)
capital	0.00330 (0.00239)	-0.0667*** (0.0163)
c. index02#c. capital		0.000885* (0.000533)
control variable	YES	YES
Region fixed effects	YES	YES
Time fixed effects	YES	YES
_cons	2.160*** (0.534)	2.280*** (0.545)
N	12235	12235
R ²	0.700	0.701

CONCLUSION

This study matches the China Digital Financial Inclusion Index with the China Rural Entrepreneurship Index and uses panel data from 1,828 county-level units in China to analyze the impact of digital finance development on rural entrepreneurship from 2014 to 2022. The main findings are as follows. First, digital finance significantly promotes rural entrepreneurship, and this conclusion holds after a series of robustness and endogeneity tests. Second, digital finance facilitates rural entrepreneurship by improving the level of agricultural mechanization and promoting industrial structure upgrading. Moreover, the level of human capital positively moderates the effect of digital finance on rural entrepreneurship. Third, digital finance significantly promotes rural entrepreneurship in the eastern and central regions of China, but its effect is not significant in the western region. Based on these findings, this study proposes the following policy recommendations.

First, the findings provide important empirical evidence on the role of digital finance in supporting rural entrepreneurship. Therefore, policymakers should attach great importance to the role of digital finance in rural entrepreneurship and broader economic development, promote its sustained and stable growth, and strengthen its inclusiveness. On the one hand, it is necessary to continuously improve new types of infrastructure in rural areas, such as 5G networks and the Internet of Things (IoT), and build a multi-level, widely covered rural financial service network to create the necessary conditions for the accelerated penetration of digital finance. On the other hand, financial institutions should be encouraged to develop customized financial products, such as contract farming loans and supply chain financing, to meet the diverse needs of rural entrepreneurial entities. At the same time, the regulatory framework should be improved by establishing a full-process supervision system covering market access, risk monitoring, information disclosure, and consumer protection, thereby effectively reducing the financing threshold and transaction costs for rural entrepreneurs.

Second, open up indirect transmission channels through which digital finance promotes rural entrepreneurship should focus on improving agricultural mechanization, promoting industrial structure upgrading, and increasing investment in scientific research and development. Specifically, efforts should be made to enhance the capacity of digital finance to serve the agricultural sector and rural areas, pay attention to the financial needs of both supply and demand sides in the agricultural machinery service market, and vigorously develop the "internet + agricultural

machinery + finance" business model. By leveraging the internet, financial institutions should be encouraged to cooperate with agricultural machinery enterprises and agricultural cooperatives, providing them with financial products such as accounts receivable pledge financing. Furthermore, the integration of digital technologies with county-level characteristic industries should be strengthened. Using big data, artificial intelligence, and IoT technologies, industrial chains should be extended and supply chains reinforced. Local advantages should be exploited, industrial functions expanded, and agriculture integrated with culture and tourism to develop new business models. This will deepen the division of labor from inter-industry to intra-industry and intra-product stages, thereby optimizing the industrial structure in rural areas. Finally, active participation in international agricultural technology exchanges should be encouraged, and investment in scientific research and personnel treatment should be increased. Governments can establish incentive mechanisms to attract returning talent and directly recruit new types of professionals with digital skills to participate in rural development. Through scenario-based training, farmers' digital tool usage capabilities and innovation awareness can be improved, creating a sustainable endogenous driver of digitalization.

Third, differentiated digital finance support strategies should be implemented to precisely empower rural development according to local characteristics. In the eastern and central regions, the focus should be on promoting the deep integration of digital finance with technological innovation, actively cultivating new business models such as digital agriculture and smart logistics, and strengthening demonstration effects on surrounding areas. In the western region, financial support should be continuously increased, and a two-pronged strategy of "basic coverage plus characteristic empowerment" should be adopted. This not only requires expanding the coverage of service outlets to reach the "last mile" but also calls for greater financial support, focusing on characteristic industries such as specialty crop and livestock farming and rural tourism, while actively innovating and applying inclusive financial products designed for these contexts.

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