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THE IMPACT OF DIGITAL INCLUSIVE FINANCE ON URBAN INNOVATION AND ENTREPRENEURSHIP

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Abstract: Innovation and entrepreneurship are of great significance to enhance the overall national strength and promoting regional development. Promoting innovation and entrepreneurship is an inevitable requirement for China to enhance the internal driving force and high-quality economic development. Based on the panel data of 279 prefecture-level cities in China from 2011 to 2019, this paper constructs a fixed-effect model to verify the relationship between digital inclusive finance and urban innovation and entrepreneurship and its influence mechanism. The study found that digital inclusive finance can significantly affect the improvement of the level of urban innovation and entrepreneurship, and the conclusion is still valid after changing the measure of urban innovation and entrepreneurship and deleting the robustness test of the provincial capital cities. Secondly, through the construction of the intermediary effect model, it is found that digital inclusive finance promotes the level of urban innovation and entrepreneurship by improving the development level and marketization degree of the Internet.
Keywords: Panel data; Digital inclusive finance; Innovation and entrepreneurship; The intermediary effect

1 INTRODUCTION

1.1 Research Background and Significance

China's economy has entered an era of high-quality and healthy development, while also being at a crucial juncture of transitioning from old to new growth drivers. Economic growth is slowing, and the pandemic has created unavoidable downward pressure on the economy. As a new driving force for China's economic growth, developing innovation and entrepreneurship is an inevitable choice and requirement for enhancing the endogenous driving force of China's economy and promoting high-quality economic and social development. As early as 2014, Premier Li Keqiang called for "mass entrepreneurship and innovation" at the World Economic Forum, aiming to stimulate the passion for innovation and entrepreneurship across society, mobilize entrepreneurial vitality, and further enhance the driving force of economic development. In 2018, the State Council proposed to create an upgraded version of innovation and entrepreneurship, further stimulate the vitality of mass entrepreneurship and innovation, and promote high-quality development of mass entrepreneurship and innovation. The 14th Five-Year Plan and the 2035 Long-Term Goals Outline also clearly propose to promote the in-depth development of innovation and entrepreneurship and optimize the layout of demonstration bases for mass entrepreneurship and innovation. It is evident that China has always attached great importance to the role of innovation and entrepreneurship in economic growth and social development, and has consistently regarded innovation as one of the national development strategies.
With the deepening development of innovation strategies, promoting urban entrepreneurship and innovation faces greater challenges. Finance is a crucial supporting factor for innovation and entrepreneurship, and the government's emphasis on formulating and implementing policies and measures related to innovation and entrepreneurship is inseparable from the support of the financial industry. The "Plan for Promoting the Development of Inclusive Finance (2016-2020)" (hereinafter referred to as the "Plan") issued by the State Council has emphasized that actively promoting inclusive finance helps to foster "mass entrepreneurship and innovation." Since the implementation of the Plan, the breadth and quality of financial services have continuously improved, and the threshold for financial services has been continuously lowered. During the pandemic, it played a key role in controlling the spread of the epidemic, restoring economic and social development, and contributing to the fight against poverty. Against this backdrop, studying the impact and pathways of digital inclusive finance on urban innovation and entrepreneurship will help deepen the understanding of urban innovation and entrepreneurship, provide a reference for policy selection and implementation to improve the level of urban innovation and entrepreneurship, and have considerable theoretical value and practical significance for consolidating the theoretical foundation of urban innovation and entrepreneurship and promoting the high-quality and healthy development of my country's economy.

1.2 Related Concepts

1.2.1 Digital inclusive finance

In 2005, the United Nations proposed inclusive finance as a new financial development model. As a developing country,

China also adopted this model in 2006, and formally proposed promoting inclusive finance in the "Decision of the CPC Central Committee on Several Major Issues Concerning Comprehensively Deepening Reform," issued at the end of 2013. In January 2016, the "Plan" also guided the development of inclusive finance to utilize innovative technologies such as the internet. Since the implementation of the "Plan, " coupled with the rapid development of information technologies such as cloud computing, big data, and blockchain, information technology and inclusive finance have accelerated their integration and innovation, giving rise to digital inclusive finance. In essence, digital inclusive finance represents a new stage in the development of inclusive finance. In 2019, the China Academy of Information and Communications Technology (CAICT) released the "White Paper on the Development of Digital Inclusive Finance (2019)," which explained that digital inclusive finance, under the condition of sustainable development with scientific cost control, uses various information and digital technologies to serve underserved urban and rural poor groups, as well as special groups in unfavorable geographical locations, providing more comprehensive, higher-quality, and lower-threshold financial services and products to micro and small enterprises.

1.2.2 Urban innovation and entrepreneurship

Urban innovation and entrepreneurship refers to pioneering entrepreneurial activities within a city that primarily rely on cutting-edge technologies, scientific knowledge, cultural heritage, and brand value as production factors. It focuses on innovation in one or more areas, such as product differentiation, technology application, service improvement, business models, management reform, organizational optimization, and marketing, emphasizing innovation, pioneering spirit, and originality. The level of urban innovation and entrepreneurship represents a city's development potential and competitiveness, and is a crucial indicator of whether a city can become an innovative city.

1.3 Research Framework and Content

First, this paper reviews relevant domestic and international literature, identifying both the achievements and shortcomings of research on digital inclusive finance and urban innovation and entrepreneurship. Second, it analyzes the impact mechanism of digital inclusive finance on urban innovation and entrepreneurship from a theoretical perspective and proposes research hypotheses. Third, using panel data from 279 prefecture-level cities in China as a sample, this paper empirically examines the relationship between digital inclusive finance and urban innovation and entrepreneurship, incorporating internet development level and marketization level as mediating variables into the mediation model to test the specific pathways through which digital inclusive finance affects urban innovation and entrepreneurship. Furthermore, the sample is divided by region to explore the heterogeneous impact of digital inclusive finance on urban innovation and entrepreneurship. Finally, the paper summarizes its research conclusions and proposes corresponding policy recommendations.

1.4 Innovations

This paper innovates in two aspects: From a research perspective, it explores the impact of digital inclusive finance on urban innovation and entrepreneurship from the perspectives of internet development level and marketization process, which helps enrich the theoretical framework of urban innovation and entrepreneurship. Regarding the selection of specific indicators, existing research on measuring the level of urban innovation and entrepreneurship still relies on relatively singular methods. Innovation provides the driving force for entrepreneurship, and entrepreneurship is the practical application of innovation; innovation and entrepreneurship are inherently complementary and interactive[1]. This paper fully considers the economic benefits brought about by the interaction mechanism between entrepreneurship and innovation, selecting a comprehensive evaluation index composed of technological big data and enterprise micro-level data to measure the level of urban innovation and entrepreneurship, hoping to better measure the quality of urban innovation and entrepreneurship output and identify market mechanisms.

2 LITERATURE REVIEW

The driving factors of innovation and entrepreneurship can be divided into two categories: external factors and internal factors. External factors mainly refer to environmental factors related to innovation and entrepreneurship, including industrial agglomeration, land resource allocation, and transportation infrastructure. Liu Maotao et al. found that the agglomeration of productive service industries has a particularly significant driving effect on urban innovation and entrepreneurship [2]. Mao Wenfeng et al. found from the perspective of land resource misallocation that it has a significant inhibitory effect on the quality of urban innovation and entrepreneurship [3]. Ji Yun et al. found that the opening of high-speed rail significantly affects the innovation vitality of large and medium-sized cities [4]. Internal factors mainly include human capital, technological innovation, and venture capital. Human capital is a key factor affecting innovation and entrepreneurship, and the optimal allocation of human capital and talent allocation can achieve the optimal scale of innovation. Liang Bang and Zhang Jianhua used data from prefecture-level cities in China to match data from the overall city level and found that digital inclusive finance can promote the improvement of urban innovation performance by promoting technological innovation [5]. In addition, L angeland et al. believed that innovation and entrepreneurship are also affected by venture capital [6].

Although China's digital inclusive finance development started late, the relevant research results are abundant. This paper focuses on the research on its effectiveness. A review of domestic and foreign literature reveals that the research on the effectiveness of digital inclusive finance is concentrated at both macro and micro levels. At the macro level, the

research mainly focuses on its impact on industrial restructuring, urban-rural income gap, and economic output growth. Song Xiaoling et al. empirically found that digital inclusive finance significantly narrows the urban-rural income gap [7]. Wang Yongjing and Li Hui further found that the effective integration of digital inclusive finance and new urbanization will have a positive spatial spillover effect on the urban-rural income gap [8]. However, the academic community has not yet reached a consensus on whether digital inclusive finance can promote economic growth. Qian Haizhang et al. found that the development of digital finance significantly promotes economic growth[9], and Zhang Zhenhua et al. obtained the interaction effect between digital inclusive finance and fiscal expenditure through the system GMM method, which is conducive to the high-quality development of China's economy[10]. However, Arcand et al. found that when financial development reaches a certain threshold, it can even have a negative impact on economic output[11]; Ge Heping et al. constructed a dynamic panel threshold data model to confirm the nonlinear relationship between digital inclusive finance and industrial structure upgrading[12]; Yi Xin and Liu Fengliang believed that financial development can promote industrial structure transformation through technological innovation[13]. Research on the micro-level effects of digital inclusive finance mainly focuses on its impact on residents' consumption and enterprise technological innovation. Ren Rong et al. used provincial panel data to find that digital inclusive finance increases residents' consumption by alleviating liquidity constraints and reducing potential uncertainty[14]. Wu Qingtian et al. used data from A-share listed companies to verify that the market access efficiency of innovative achievements is a key mechanism by which digital inclusive finance affects enterprise technological innovation[15]. In summary, research on digital inclusive finance and urban innovation and entrepreneurship still lacks attention.

Based on the above, digital inclusive finance has always been a hot topic in academic research, but some shortcomings remain: research on its effectiveness focuses on the macro and micro levels, with few studies examining its driving effect on urban innovation and entrepreneurship at the meso level. Under the backdrop of the new normal of the economy, promoting urban innovation and entrepreneurship is both urgent and necessary. With the deepening development of the mass entrepreneurship and innovation strategy, exploring whether digital inclusive finance is conducive to the development of urban innovation and entrepreneurship has undeniable practical significance.

3 THEORETICAL ANALYSIS AND RESEARCH HYPOTHESES

3.1 Digital Inclusive Finance and Urban Innovation and Entrepreneurship

Digital inclusive finance plays a crucial role in innovation and entrepreneurship, and its impact can be divided into two aspects: its influence on innovation and its influence on entrepreneurship. Regarding entrepreneurship, most studies indicate that the development of digital inclusive finance significantly promotes entrepreneurship, and all three sub-dimensions of digital inclusive finance—coverage, usage, and the level of digital technology support services—can catalyze entrepreneurship [16]. In the early stages of entrepreneurship, businesses face many uncertainties and various risks of failure, while digital inclusive finance can provide stable financial support during the entrepreneurial development process, improving and safeguarding the financial environment for urban entrepreneurship. Feng Dawei et al. found that digital inclusive finance can expand access to financing by alleviating credit constraints and promote individual entrepreneurship by increasing financial participation[17].

At the innovation level, existing research has also demonstrated the crucial role of financial development in enhancing innovation levels [18-19]. Further analysis reveals that digital inclusive finance primarily promotes enterprise technological innovation by reducing financing constraints and costs [20-21], avoiding resource waste and moral hazard [22], and optimizing support conditions for enterprise technological innovation[23]. Furthermore, digital inclusive finance promotes regional innovation levels by improving regional credit resources and boosting resident consumption [24-25]. In summary, the development of digital inclusive finance primarily enhances urban innovation and entrepreneurship levels by improving the financing environment for innovation and entrepreneurship and by effectively supplementing traditional finance [26]. Therefore, this paper proposes the first hypothesis:

Hypothesis 1 : Improved digital financial inclusion will help urban innovation and entrepreneurship.

3.2 The Impact Mechanism of Digital Inclusive Finance on Urban Innovation and Entrepreneurship

Digital inclusive finance is the latest development of inclusive finance in the digital age. Relying on certain network platforms and information technology, it can reduce the cost of information collection and processing for innovative and entrepreneurial entities, thus alleviating information asymmetry and enhancing their confidence in innovation and entrepreneurship. When the level of urban internet development is relatively weak, it is usually constrained by technological limitations, resulting in a weaker impact of digital inclusive finance on urban innovation and entrepreneurship. As the level of internet development improves, the service scope and reach of digital inclusive finance will be further extended, leading to a more significant driving effect on urban innovation and entrepreneurship. Zhan Yong and Xu Leshowed that digital inclusive finance belongs to the "Internet + finance industry," improving information transparency and accelerating the flow of funds, thereby reducing entrepreneurial risks and increasing the likelihood of entrepreneurship[27]. Huang et al. also found that digital inclusive finance can utilize internet technology to improve the efficiency of loan approval by financial institutions, thereby promoting innovation and entrepreneurship[28].

From the perspective of market integration, digital inclusive finance can break down spatial and temporal barriers, promoting the free flow of factors such as capital and knowledge among capital markets [29], thereby creating a fair

and equitable market environment for innovation and entrepreneurship. Furthermore, with market development, information transparency is increasing, regulatory systems and legal frameworks are becoming more complete and robust, intellectual property rights are being more effectively protected, and market competition is becoming increasingly fair and transparent, creating a favorable atmosphere for innovation and entrepreneurship and stimulating the enthusiasm for innovation and entrepreneurship in cities. Based on the above analysis, the following hypotheses are proposed:

Hypothesis 2: Digital inclusive finance can promote urban innovation and entrepreneurship by improving the level of internet development.

Hypothesis 3 : Digital inclusive finance can promote the improvement of urban innovation and entrepreneurship by improving the level of marketization.

4 RESEARCH DESIGN

4.1 Econometric Model Setting

Based on the above theoretical analysis, in order to empirically test the hypotheses proposed in this paper, the following static panel benchmark model is constructed:

$$inn_{i,t}=\beta_0+\beta_1 ifi_{i,t}+\beta_2 X_{i,t}+\lambda_i+\mu_t+\varepsilon_{i,t} \quad (1)$$

In the formula, the subscripts i and t represent an individual city and the corresponding year, respectively. The dependent variable inn is the level of innovation and entrepreneurship in the city, the independent variable ifi is the level of digital inclusive finance, and X is a series of control variables that affect the innovation and entrepreneurship in the city, including the level of economic development, the level of financial development, the level of fiscal expenditure, the level of industrial structure, the intensity of scientific research expenditure, etc., λ_i representing the fixed effect of the individual city, μ_t representing the fixed effect of the city over time, and $\varepsilon_{i,t}$ representing the random disturbance term.

4.2 Variable Measurement and Explanation

4.2.1 Dependent variable: urban innovation and entrepreneurship (inn)

Most scholars consider indicators of urban innovation and entrepreneurship from the perspective of a single dimension of innovation or entrepreneurship, neglecting the complementary relationship between the two. This paper draws on the research approach of Liu Maotao et al. and uses the "Langrun Longxin China Regional Innovation and Entrepreneurship Index 2019" from the National School of Development at Peking University to calculate a comprehensive evaluation index by weighting the secondary indicators proportionally to measure the level of urban innovation and entrepreneurship[2]. Table 1 shows the evaluation system and weighting ratio of this index.

Table 1 Innovation and Entrepreneurship Quality Evaluation Index System

Primary indicators	Secondary indicators	Weighting percentage
New Enterprise	Number of newly registered enterprises	20
Attracting foreign investment	The number of new foreign corporate investments	15
Attracting venture capital	The amount of new venture capital	25
Number of patents granted	Number of newly granted invention patents	12.5
	Number of newly published utility model patents	7.5
	The number of newly published design patents	5
Number of trademark registrations	Number of newly registered trademarks	15

4.2.2 Explanatory variable: digital inclusive finance index (ifi)

This paper utilizes data on inclusive finance released by the Institute of Digital Finance at Peking University and selects a general indicator for digital inclusive finance as the explanatory variable. This indicator system, a result of joint research between the Institute of Digital Finance at Peking University and Ant Financial, is based on traditional methods of measuring inclusive finance while incorporating advancements in digital technology. It has been widely applied in existing academic research on inclusive finance. This index encompasses the coverage, depth of use, digitalization level of inclusive finance, and various types of financial services within the depth of digital finance applications, including payment, credit, lending, and investment. A higher index indicates better development of digital inclusive finance within a region.

4.2.3 Control variables

(1) Economic development level (lngdp): The level of innovation and entrepreneurship in a city is closely related to the level of economic development in that city. The higher the level of economic development in a region, the more favorable the macro environment for innovation and entrepreneurship will be, and the more conducive it will be to stimulating innovation and entrepreneurship in the city[30].

(2) Financial Development Level (FIN): A sound internal financial mechanism can disperse or reduce various risks faced by enterprises and boost their confidence in innovation and entrepreneurship[31] The more perfect a region's financial system is, the better its financial development level is, and the more conducive it is to innovation and entrepreneurship. This paper uses the ratio of outstanding loans of financial institutions to GDP as a representative of

the financial development level.
(3) Fiscal expenditure level (gov) : As an important supporter and participant in urban innovation and entrepreneurship, the government provides important guarantees for the development of innovation and entrepreneurship activities. This paper uses local government general budget expenditure to represent the fiscal expenditure level.
(4) Industrial Structure Level (is): A reasonable industrial structure provides an important source of motivation for urban innovation and entrepreneurship. The higher the degree of industrialization and modernization, the more developed the secondary and tertiary industries are. This paper uses the proportion of the total amount of the secondary and tertiary industries to GDP to represent the industrial structure level.
(5) Research and development expenditure level (rd): Government subsidies are beneficial to the innovation efficiency of enterprises, both before and after the event [32]. This paper uses the proportion of government science and technology research and development expenditure to the general budget expenditure of the government to represent this.

4.2.4 Mediating variable M

(1) Internet development level (net)
Currently, there are three main methods used in research to measure the level of internet development: the number of internet users, internet industry revenue, and internet penetration rate. Based on data availability, this paper adopts the approach of most scholars, using internet penetration rate as a proxy variable for the level of internet development, specifically represented by the number of broadband internet users divided by the year-end registered population of the city.
(2) Level of marketization (mar)
The Fan Gang Marketization Index was used as a proxy variable for the level of marketization (Table 2).

Table 2 Variable Definition and Description

type	Variable name	Variable symbol	Indicator Explanation
Explanatory variable	Urban Innovation and Entrepreneurship	inn	Langrun Longxin China Regional Innovation and Entrepreneurship Index Weighting
Explanatory variables	Digital Inclusive Finance	ifi	Peking University Digital Inclusive Finance Index
control variables	Economic development level	lngdp	Logarithm of GDP per capita
	Financial development level	fin	Financial institutions' loan balance / GDP
	Industrial structure level	Is	Total output of secondary and tertiary industries / GDP
	Fiscal expenditure level	gov	Local government general budget expenditure
	Research expenditure intensity	rd	Government science spending / GDP
Mediator variables	Internet development level	net	Number of broadband internet users / City's year-end registered population
	Marketization	mar	Fan Gang Marketization Index

4.3 Data Sources and Processing

Based on existing research and data availability, this paper selects panel data from 279 prefecture-level cities in China for basic research. After removing city samples with significant variable omissions, a final total of 2204 observations were obtained. The digital inclusive finance related index comes from the Digital Finance Research Center of Peking University, and the urban entrepreneurship and innovation index comes from the Langrun Longxin Regional Innovation and Entrepreneurship Index of the National School of Development at Peking University. Control variables are from the *China Urban Database*, *China Urban Statistical Yearbook*, and *China Statistical Yearbook*, with some missing data sourced from the statistical yearbooks of the corresponding provinces. Mediating variables are from relevant years in the *Statistical Report on Internet Development in China* and the Fan Gang Marketization Index.
Table 3 presents descriptive statistics of the relevant variables in this paper, showcasing the general outline of the sample data. It can be seen that the data dimensions are relatively consistent, providing a data foundation for further analysis. Furthermore, the table reveals significant differences in the development level of digital inclusive finance and the vitality of innovation and entrepreneurship across different regions.

Table 3 Descriptive Statistics of Variables

variable	Sample size	average value	Standard deviation	Minimum value	Maximum value
inn	2,541	51.70	25.15	3.285	100
ifi	2,540	164.4	65.21	17.02	321.6
lngdp	2,524	15.41	0.831	12.66	18.84
fin	2,532	1.159	1.005	0.132	16.74
gov	2,533	0.253	0.284	0.0154	6.041
rd	2,531	314.1	382.0	12.82	6,310

is	2,215	0.878	0.0766	0.501	1.000
mar	2,507	11.48	2.103	4.960	17.47
net	2,459	0.222	0.182	0.01	1.890

5 EMPIRICAL ANALYSIS

5.1 Benchmark Regression

This paper uses Stata 16.0 software for hypothesis testing and regression analysis of the model. The estimation results are shown in Table 4. The regression results show that the regression coefficient measuring digital inclusive finance (ifi) is positive and reaches a statistical significance level of 1%, indicating that digital inclusive finance is an important driving force for urban innovation and entrepreneurship. Therefore, hypothesis 1 is verified. Regarding control variables, the regression results of the three variables—urban economic development level (lngdp), R&D expenditure intensity (rd), and industrial structure level (is)—are highly significant and positively correlated with urban innovation and entrepreneurship (Inn). The regression result for financial development level (fin) is also relatively significant. Higher regional economic development and financial development levels, better industrial structure, and greater government R & D expenditure intensity all reflect a favorable economic environment. This also indicates that a better economic environment is conducive to stimulating urban innovation and entrepreneurship vitality and improving the quality of innovation and entrepreneurship, which is consistent with the expected conjecture of this paper. However, it can be seen that the relationship between the level of fiscal expenditure and urban innovation and entrepreneurship is negative, contrary to expectations. This may be because the incentive effect of government expenditure on the innovation capabilities of enterprises at different stages of their life cycle varies. Government subsidies have an inverted U-shaped relationship with enterprise innovation and entrepreneurship [33]. When government subsidies for innovation and entrepreneurship reach their maximum value, the incentive effect may be squeezed out as incentive input increases. In addition, government expenditure encompasses multiple aspects, and its specific impact on urban innovation and entrepreneurship requires a process. For example, the proportion of government investment in scientific research is needed to accurately grasp the government's support for innovation and entrepreneurship.

Table 4 Model Estimation Results

variable	(1)	(2)	(3)	(4)
ifi	0.021***	0.021***	0.021***	0.025***
	(4.55)	(4.57)	(4.57)	(5.01)
lngdp	5.685***	5.726***	5.513***	5.289***
	(6.18)	(6.20)	(6.12)	(4.95)
fin	0.051	0.172	0.131	0.608*
	(0.47)	(0.59)	(0.46)	(1.70)
gov		-0.511	-1.132	-0.125
		(-0.46)	(-1.18)	(-0.07)
rd			0.001**	0.002**
			(2.07)	(2.08)
is				32.887***
				(2.73)
Constant	-32.521**	-33.135**	-30.044**	-55.374***
	(-2.40)	(-2.44)	(-2.27)	(-3.67)
Individual fixed effects	have	have	have	have
Year fixed effect	have	have	have	have
N	2516	2510	2509	2204
id	284	284	284	279
R 2	0.048	0.049	0.051	0.073

Note: The values in parentheses are statistical measures, *** p<0.01, ** p<0.05, * p<0.1.

5.2 Robustness Test

Two types of robustness tests were conducted on the regression results in Table 4, and Table 5 shows the results of these two robustness tests. First, a robustness test was performed by replacing the weighted innovation and entrepreneurship index in the baseline regression with the unit area index of urban innovation and entrepreneurship as the measure of the dependent variable. Second, a second regression test was conducted after removing 28 resource-rich and economically developed provincial capitals from the sample. The results show that the results remain robust regardless of whether the dependent variable was changed or the influence of provincial capitals was removed.

Table 5 Robustness Test Results

variable	Change the explained variable	Excluding provincial capitals
ifi	0.016***	0.026***
	(4.90)	(4.93)
lngdp	3.333***	5.685***
	(4.43)	(4.91)
fin	0.490**	0.517
	(1.97)	(1.31)
gov	-0.694	1.633
	(-0.57)	(1.34)
rd	0.001**	0.002**
	(2.11)	(1.98)
is	22.829***	30.769**
	(2.65)	(2.48)
Constant	-17.403*	-62.627***
	(-1.67)	(-4.00)
Individual fixed effects	have	have
Year fixed effect	have	have
N	2204	1980
R 2	0.0749	0.0720

Note: The values in parentheses are statistical measures, *** p<0.01, ** p<0.05, * p<0.1.

5.3 Mediation Effect Analysis

Following the analysis of the relationship and impact between digital inclusive finance and urban innovation and entrepreneurship, this paper further employs a mediation effect model, using the level of internet development and marketization as mediating variables to examine the specific pathways through which digital inclusive finance influences urban innovation and entrepreneurship. Drawing on the mediation effect model established by Baron and Kenny (1986) and Wen et al. (2014), where M represents the two mediating variables in this paper, the mediation effect model is as follows[34]:

$$inn_{i,t}=\theta_1+cifi_{i,t}+\lambda X_{i,t}+\mu_{i,t} \quad (2)$$

$$M_{i,t}=\theta_2+aifi_{i,t}+\lambda X_{i,t}+\mu_{i,t} \quad (3)$$

$$inn_{i,t}=\theta_3+c'ifi_{i,t}+bM_{i,t}+\lambda X_{i,t}+\mu_{i,t} \quad (4)$$

This paper refers to Wen Zhonglin and Ye Baojuan (2014) to test the mediation effect using stepwise regression[35]. The stepwise regression logic consists of three steps: First, test the coefficient c of equation (2), that is, the overall effect of the independent variable ifi on the dependent variable inn. If the coefficient c is significant, it is rejected. Second, test the coefficient a of equation (3), that is, the effect of the independent variable H_0：c=0ifi on the mediating variable M, that is, test the effect of the independent variable ifi on the marketization level mar and the Internet development level net. Third, after controlling for the mediating variable M, test the coefficients and coefficient b of equation (c'4). If the coefficient a is significant, it is rejected, and if the coefficient b is also rejected, the mediation effect is significant. If the coefficients c and a and b are significant and H_0：a=0c'not significant, then there is a complete mediation effect; otherwise, it is a partial mediation effect. Table 6-7 shows the estimation results of the mediation effect.

As shown in columns (1) to (3) of Table 6, when the level of marketization is the mediating variable, digital inclusive finance and innovation and entrepreneurship are highly significantly positively correlated, and digital inclusive finance also shows a significant positive correlation with the level of marketization. When the marketization index is controlled as the mediating variable, the regression coefficient of digital inclusive finance is still significant, indicating that there is a partial mediating effect.

Table 6 The Mediating Effect of Marketization Level

variable	(1)	(2)	(3)
ifi	0.085***	0.017***	0.073***
	(11.32)	(30.47)	(8.39)

mar			0.567**
			(2.09)
Constant	37.806***	8.720***	33.541***
	(28.62)	(89.58)	(12.36)
N	2540	2507	2507
R 2	0.0477	0.270	0.0477
F	128.2	928.3	63.7

Note: The values in parentheses are statistical measures, *** p<0.01, ** p<0.05, * p<0.1.

Further analysis of columns (1) to (3) in Table 7 shows that when the level of internet development is the mediating variable, digital inclusive finance is highly significantly positively correlated with both the level of innovation and entrepreneurship and the level of internet development. When the influence of the three factors is controlled for by the level of internet development, the regression coefficient of digital inclusive finance is no longer significant, indicating that the level of internet development has a complete mediating effect. Furthermore, referring to the Sobel test conducted by Wen Zhonglin et al. on the two mediating effects, the results show that the Sobel test p-values for both the level of internet development and the level of marketization are below 0.05, indicating the existence of a mediating effect. Moreover, the proportion of the level of internet development in the total effect is higher than that of the level of marketization, indicating that the mediating effect of the level of internet development is more significant, consistent with the results of the stepwise regression test. Therefore, hypotheses 2 and 3 are verified.

Table 7 The Mediating Effect of Internet Development Level

variable	(1)	(2)	(3)
ifi	0.085***	0.001***	- 0.003
	(11.32)	(29.56)	(-0.39)
net			60.646***
			(20.63)
Constant	37.806***	-0.014*	33.541***
	(28.62)	(-1.67)	(12.36)
N	2540	2459	2459
R 2	0.0477	0.262	0.187
F	128.2	874.1	283.0

Note: The values in parentheses are statistical measures, *** p<0.01, ** p<0.05, * p<0.1.

5.4 Heterogeneity Analysis

This paper divides the sample into eastern, central and western regions according to administrative geographical areas for heterogeneity analysis, and attempts to explore the heterogeneous effects of digital inclusive finance on urban innovation and entrepreneurship in different regions. It is hoped that the research conclusions will provide ideas for implementing relevant policies according to local conditions.

Table 8 Subsample Regression Results

variable	(1) Eastern	(2) Central	(3) Western
ifi	-0.013*	0.014	0.038***
	(-1.79)	(1.18)	(5.24)
lngdp	3.590**	-1.441	8.602***
	(2.44)	(-0.73)	(5.05)
fin	-4.088**	0.361	1.451***
	(-2.43)	(0.80)	(4.55)
gov	11.741	-0.542	-1.610
	(0.80)	(-0.34)	(-0.20)
rd	0.002	0.001**	0.004
	(1.06)	(2.29)	(1.44)
is	57.543**	26.036	10.721
	(2.40)	(1.05)	(0.61)

Constant	-40.876	35.961	-88.873***
	(-1.58)	(1.16)	(-3.75)
Individual fixed effects	have	have	have
Year fixed effect	have	have	have
N	885	841	478
R 2	0.0987	0.126	0.0131

Note: The values in parentheses are statistical measures, *** p<0.01, ** p<0.05, * p<0.1.

As shown in Table 8, in the more economically developed eastern region, the regression coefficient of digital inclusive finance is significantly negative; the regression coefficient in the central region begins to turn positive; and the regression coefficient in the western region not only meets expectations but also reaches a significance level of 10 %. This indicates that the role of digital inclusive finance in promoting urban innovation and entrepreneurship is gradually increasing in the eastern, central, and western regions, especially in the relatively underdeveloped western region where the effect is most obvious.

6 RESEARCH CONCLUSIONS AND RECOMMENDATIONS

This paper examines the impact of digital inclusive finance on urban innovation and entrepreneurship based on panel data from 279 prefecture -level cities in China from 2011 to 2019, using internet penetration rate and marketization level as mediating variables. The results show that: First, the development of digital inclusive finance can significantly improve the level of urban innovation and entrepreneurship. This conclusion remains robust even after changing the measurement method of the explained variable and excluding provincial capitals. Second, this paper attempts to test the specific pathways through which digital inclusive finance affects urban innovation and entrepreneurship by constructing a mediation effect model. The test results show that digital inclusive finance improves the level of urban innovation and entrepreneurship by increasing internet development and marketization. Finally, regional heterogeneity analysis reveals that the promoting effect of digital inclusive finance on urban innovation and entrepreneurship varies across different regions of China, with a greater effect in central and western China. Based on these findings, the following policy recommendations are proposed:

First, we must continue to steadily advance the development of digital inclusive finance, increase the coverage of basic financial services, fully leverage and realize the comparative advantages of digital inclusive finance and traditional finance, and promote healthy competition and complementarity between the two. Research has found that urban innovation and entrepreneurship are also influenced by various factors such as the level of economic development, financial development, and industrial structure. Therefore, it is also necessary to improve the financial regulatory system, enhance the comprehensive service capabilities of digital finance, promote industrial optimization and upgrading, increase investment in scientific research and incentives for scientific and technological innovation, and improve policies and mechanisms for the transformation of scientific and technological innovation achievements, thereby improving the output level and quality of innovation and entrepreneurship.

Second, strengthen the construction of network information service infrastructure in the financial industry. Despite the rapid development of the internet in the digital economy era, it is still necessary to strengthen and optimize network infrastructure, continue to improve internet penetration, and further extend the reach of digital inclusive finance. Efforts should be made to lower the barriers to information access and reduce the costs of information verification for various urban innovation and entrepreneurship entities, thereby mitigating the risks of information asymmetry. In short, we must continue to leverage the maximum advantages of the integration of inclusive finance and digital information technology to support urban innovation and entrepreneurship.

Third, we must accelerate the marketization process and create a favorable market environment. We should continue to promote the positive role of digital inclusive finance in improving the marketization of innovation and entrepreneurship, stimulating the innovation and entrepreneurship vitality of enterprises and individuals. The government should respect the dominant position of the market, further streamline administration and delegate power, reduce excessive intervention in the economy, allow all sectors to develop according to their own laws, and let market competition achieve survival of the fittest, thereby driving innovation and entrepreneurship. We should improve relevant laws, regulations, and systems, strengthen effective market supervision, and provide institutional guarantees for the effective flow of resources.

Fourth, digital inclusive finance has a regionally heterogeneous effect on innovation and entrepreneurship across different regions. Governments should formulate differentiated development strategies for inclusive finance based on the actual development of digital inclusive finance in different regions. For the economically developed eastern regions with a high level of digital inclusive finance development, the development of digital inclusive finance should continue to be steadily promoted. However, for the central and western regions, where digital inclusive finance development is relatively lagging, but where its role in promoting urban innovation and entrepreneurship is most significant, governments should increase incentives through mechanisms and policies, formulate guidelines that align with local development, and ensure that digital inclusive finance leverages its inclusive characteristics to better promote the integration of digital inclusive finance with innovation and entrepreneurship, thereby fostering high-quality and healthy

development across all regions of the country.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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