

Entrepreneurial effects and impact mechanisms of financial inclusion

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Abstract. The development of inclusive finance is crucial for China's overall prosperity, fostering mass entrepreneurship and innovation. This paper utilizes data from 2011 to 2019, including the digital financial inclusion index and China's innovation and entrepreneurship regional index, to construct a fixed-effects model. It empirically examines how digital financial inclusion influences innovation and entrepreneurship. Results show that digital inclusive finance fosters innovation and entrepreneurship among residents, with varying effects across regions, particularly in the East and West. The study explores intermediary mechanisms, revealing that digital inclusive finance enhances residents' entrepreneurial innovation by improving credit quality and scale while reducing non-performing loan balances. However, expanding insurance coverage and digital inclusive financial services may have a substitution effect, weakening the impact of inclusive financial development on innovation and entrepreneurship, especially where insurance coverage is more extensive. Moreover, the paper suggests further investigation into the intermediary pathway linking digital inclusive finance with residents' innovation and entrepreneurship through economic development levels. Enhancing loan quality and quantity is essential to provide entrepreneurs with robust financial support.

Keywords: Digital financial inclusion; Innovation and entrepreneurship; Credit; Insurance; Economic growth;

1. Introduction

Entrepreneurship and innovation have become a crucial employment option, playing a significant role in economic upgrading, employment expansion, livelihood improvement, and social innovation. However, there are still limitations that hinder entrepreneurship. These include financial constraints, lack of knowledge and skills, intense market competition, and risk and uncertainty. Lack of capital is a common obstacle for entrepreneurs, while insufficient knowledge and experience also discourage some. To sustain economic growth and enhance employment quality, it is necessary to delve into the factors influencing entrepreneurial decision-making.

The existing literature has shown that financial services are an important factor influencing entrepreneurship (Zhang, 2019). In real life, the availability and utilization of financial services vary across regions, impacting the entrepreneurial motivation of residents. Inclusive finance aims to provide affordable and effective financial services to all strata and groups in society, based on equal opportunity and commercial sustainability. The development of inclusive finance is seen as vital to fostering sustainable and balanced growth in the financial industry, promoting mass entrepreneurship and innovation, and facilitating economic transformation and upgrading.

Digital financial inclusion has emerged as financial institutions adopt Internet technology, offering Internet-based financial products and services. It catalyzes achieving the goal of "mass entrepreneurship and innovation". A joint research group from Peking University's Digital Finance Research Centre and Ant Technology Group has developed a set of digital inclusive finance indices, measuring the breadth of coverage, depth of use, and level of digitization. These indices serve as valuable data for further research.

There have been a large number of studies exploring the relationship between digital financial inclusion and entrepreneurship. Zhang Lin and Wen Tao (2020) chose to use the sum of the total number of private enterprise and individual employment, the number of private enterprise households and the number of individual households in each province and city to reflect the entrepreneurial

behavior of the residents, while Deng Xiaona (2019) and Feng Yongqi (2021) chose to use "(number of individual employment + number of private enterprise investor employment)/resident population" to measure the provincial resident entrepreneurial participation rate to measure the variable of entrepreneurship, and Xie Xunli(2018) selects the data of the number of newly registered enterprises with information. However, the data selection and measurement of the above dependent variables are relatively one-sided.

This paper innovates in two key ways compared to existing studies. Firstly, it offers macro-level empirical evidence, departing from the prevalent use of microdata with households as the sample unit, which often suffers from sample limitations and relies heavily on cross-sectional data. By utilizing panel data, this study mitigates external influences and enhances variable analysis. Secondly, unlike other literature employing diverse evaluation weighting methods for financial inclusion indices, this paper directly utilizes readily available databases such as China's Regional Innovation and Entrepreneurship Index and Digital Financial Inclusion Index, compiled by professional institutions. These databases undergo rigorous collection and processing to ensure research reliability and accuracy. Notably, this study incorporates the China Innovation and Entrepreneurship Regional Index from Peking University's Enterprise Big Data Research Centre as the dependent variable, constructing objective multi-dimensional entrepreneurship indicators spanning five dimensions.

2. Theoretical analysis and research hypotheses

Increased financial literacy can significantly promote household participation in entrepreneurial activities (Yin, 2015). The development of digital finance is conducive to achieving inclusive economic growth in China and is more conducive to entrepreneurship for rural rather than urban residents (Zhang et al., 2019). Xie Xunli et al. (2018) found that digital financial inclusion and its sub-indices on different dimensions all have a significant role in promoting innovation and entrepreneurship.

And the existing literature has explored some of the mechanisms and paths of the promotional effect of the level of inclusive financial development on entrepreneurship; inclusive finance promotes entrepreneurial decision-making of households significantly by improving the level of household-owned wealth, household risk attitudes, and the convenience of third-party payment (Zhang, 2019); inclusive finance promotes entrepreneurship of the residents by alleviating financial exclusion, lowering the threshold of loans, and providing diversified financial services (Deng, 2019); inclusive finance promotes residents' entrepreneurship by lifting financial constraints, promoting the popularity of transaction media, and improving risk perception and management capabilities (Li, 2020). From an indirect perspective, inclusive finance provides residents with entrepreneurial conditions and opportunities by promoting economic increase and fostering human capital, which in turn promotes residents' entrepreneurship (Deng, 2019).

Existing literature suggests that the impact of digital financial inclusion on entrepreneurship warrants further exploration. This paper initiates theoretical analyses and empirically tests this relationship using panel data from 31 provinces (excluding Hong Kong, Macao, and Taiwan) from 2011-2019. It proposes three pathways through which financial inclusion influences entrepreneurial decision-making: first, by enhancing credit availability and alleviating financial constraints; second, by broadening insurance coverage and mitigating risks; and third, by fostering economic growth, increasing income, and improving living standards. Based on empirical findings, this paper presents key conclusions and policy suggestions.

2.1 Financial inclusion and entrepreneurship

The development of financial inclusion significantly influences innovation and entrepreneurship. International bodies like the Alliance for Financial Inclusion (AFI) define financial inclusion through three aspects: prompt accessibility, ease of use, and quality. Digital financial inclusion enhances access to financial services across a broader geographical scope, thereby expanding the

entrepreneurial community. It also lowers borrowing thresholds and credit costs for underserved groups, stimulating innovation and startup initiatives. Moreover, digital inclusive finance offers higher quality, standardized financial services to remote and marginalized communities, providing them with the necessary capital and confidence for entrepreneurship.

Accordingly, Hypothesis H1 is formulated: the increase in the level of development of digital inclusive finance will promote innovation and entrepreneurship among the population.

2.2 Credit availability and entrepreneurship

Sufficient capital is crucial for sustainable business operations. It motivates entrepreneurship, enhances its level, and improves business sustainability. However, financing constraints often hinder enterprise development. Established credit markets can help alleviate the problem of capital scarcity, addressing factors like limited loan sizes for micro and small enterprises or inadequate services from local financial institutions. Digital inclusive finance can overcome these constraints, making it easier for residents to access credit, lowering the entrepreneurship threshold, and increasing the likelihood of starting a business. By providing loans and financing options at lower costs, digital financial inclusion facilitates easier access to capital for entrepreneurs, enabling them to launch or expand their businesses.

Accordingly, hypothesis H2 is formulated: the level of digital financial inclusion development will further promote innovation and entrepreneurship by increasing credit accessibility.

2.3 Level of insurance coverage and entrepreneurship

The World Bank's 2014 Global Survey on Inclusive Finance identifies four dimensions of inclusive finance: savings, payments, credit, and commercial insurance. Inclusive insurance aims to provide affordable and effective insurance services to all segments of society, ensuring equal opportunities and commercial sustainability. Small and micro-enterprises, farmers, urban low-income individuals, the poor, people with disabilities, the elderly, and other special groups are vulnerable to risks that impact their economic behavior, making them more conservative. Widely accessible insurance services can offer risk protection, alleviating concerns and encouraging these individuals to take initiative and start businesses. In areas with greater financial inclusion, residents have increased access to comprehensive insurance services, fostering a positive and proactive attitude towards innovative entrepreneurship.

Accordingly, hypothesis H3 is proposed: the level of digital financial inclusion development will further promote innovation and entrepreneurship by increasing the level of insurance coverage.

2.4 Level of economic growth and entrepreneurship

The economic growth effect of financial inclusion promotes entrepreneurship. Financial inclusion has been regarded as an important mechanism for promoting economic growth, as reflected in the impact of financial depth and breadth on economic growth. The rapid economic development has increased the income and improved the material level for the residents, and provided rare entrepreneurial conditions and entrepreneurial opportunities, which have improved the entrepreneurial ability of the residents, thus stimulating their entrepreneurial vigor. On the one hand, the good or bad level of the economy affects the scale, structure, and trend of the entrepreneurial environment; on the other hand, the higher income and increased wealth brought about by economic development not only provide a good economic foundation and external conditions for entrepreneurship but also affect entrepreneurship by changing career choices and enhancing entrepreneurial confidence.

Accordingly, hypothesis H4 is proposed: the level of digital financial inclusion development will further promote innovation and entrepreneurship by increasing the level of economic growth.

3. Empirical research design

3.1 Empirical modeling

Drawing on previous research on the impact effect of financial inclusion on entrepreneurship (Deng, 2019; Zhang, 2020), this paper sets up the following multiple linear regression model to test the entrepreneurial effect of financial inclusion:

$$II_{it} = \mu + \alpha * FI_{it} + \beta * Z + \varepsilon \quad (1)$$

Where II stands for the Innovation Index of Entrepreneurship, FI is the core explanatory variable of the Finance Index of Digital Inclusion, and Z represents other control variables. α 、 β is the regression coefficient of the variable, i represents the ith province and city, and t represents the t th year. μ denotes individual differences in the cross-section of each province and city that do not vary over time, and ε is the random disturbance term. In this paper, referring to previous studies, the multiple linear regression model is obtained when the income level In, consumption expenditure AS, patent application AP, public service PS, industrial structure Te, education level Ed, and labor force participation Un are introduced as control variables Z:

$$II_{it} = \mu + \alpha * FI_{it} + \beta_1 * In_{it} + \beta_2 * AS_{it} + \beta_3 * AP_{it} + \beta_4 * PS_{it} + \beta_5 * Te_{it} + \beta_6 * Ed_{it} + \beta_7 * Un_{it} + \varepsilon \quad (2)$$

The above model can only examine the direct influence mechanism of the level of financial inclusion on the entrepreneurial effect, for the test of the indirect mechanism, In this paper, we add the mediating variables of the scale of the Loan, the degree of insurance coverage(ID), and the economic growth situation(AG) as well as the cross terms of the mediating variables and the core explanatory variable (FI) respectively based on (2), and observe the change of the direction of their regression coefficients. The econometric model is as follows:

$$II_{it} = \mu + \alpha_1 * FI_{it} + \alpha_2 * Lo_{it} + \alpha_3 * FI_{it} * Lo_{it} + \beta * Z + \varepsilon \quad (3)$$

$$II_{it} = \mu + \alpha_1 * FI_{it} + \alpha_2 * ID_{it} + \alpha_3 * FI_{it} * ID_{it} + \beta * Z + \varepsilon \quad (4)$$

$$II_{it} = \mu + \alpha_1 * FI_{it} + \alpha_2 * AG_{it} + \alpha_3 * FI_{it} * AG_{it} + \beta * Z + \varepsilon \quad (5)$$

3.2 Variables and data

The period of all indicators is 2011-2019, and the sample covers 31 provincial-level administrative regions in China (excluding Hong Kong, Macao, and Taiwan). The meaning of each variable and data sources are listed below.

Table 1 Meaning of variables and data description

Variable type	variable name (Abbreviations)	unit (of measure)	Data sources
explanatory variable	Innovation Index (II)	-	Peking University Open Research Data Platform
Core explanatory variables	Digital Inclusive Finance Index (FI)	-	Digital Finance Research Centre, Peking University
intermediary variable	Scale of Loanl (Lo)	billions	China Financial Statistics Yearbook
	Insurance Density (ID)	Yuan/person	China Financial Statistics Yearbook
	Economic growth (Average GDP, AG)	Yuan/person	Data from the National Statistical Office
control variable	Income level (In)	the Yuan	Data from the National Statistical Office

	consumer spending (Average Sales, AS)	Ten thousand yuan/person	China Financial Statistics Yearbook
	Average Patent (AP)	Number of cases per 10,000 persons	Data from the National Statistical Office
	Public Service (PS)	Ten thousand yuan/person	Data from the National Statistical Office
	Tertiary (Te)	100 million yuan	Data from the National Statistical Office
	Educational level (Ed)	10 thousand yuan	Data from the National Statistical Office
	Labor force participation (Unemployment, Un)	10 thousand number of people	Data from the National Statistical Office

3.2.1 Explained variables

Peking University's Enterprise Big Data Research Centre created the Innovation Index (IRIEC) to assess China's regional innovation and entrepreneurship using enterprise data from the 2011-2019 national registration database. This index offers a real-time, multi-dimensional evaluation of regional innovation and entrepreneurship, reflecting each region's vitality and performance in these areas. The data is sourced from Peking University's enterprise big data research platform.

3.2.2 Core explanatory variables

Peking University Digital Finance Research Centre and Ant Technology Group jointly developed the Digital Inclusive Finance Index, comprising dimensions like coverage, usage depth, and digitization level. The index, employing 33 specific indicators, covers payment, credit, insurance, deposit, investment, and money fund. Using the Hierarchical Analysis Method, a widely-used compilation approach, the group created the Peking University Digital Inclusive Finance Index for 31 provinces, 337 cities, and around 2,800 counties in China. This paper focuses on provincial-level panel data from 2011-2019.

3.2.3 Mediating variables

(1) Scale of loan1

In this paper, to gauge the scale of credit issuance, the author utilizes data from Bank of Communications deposits and loans in local and foreign currencies referred to as loan1. Additionally, for robustness testing, alternate measures such as Banking Financial Institutions Loans (loan2), Commercial Banks' Non-Performing Loans (Non-Performing Loan Balance), and Non-Performing Loan Ratio (BLR) are also considered. These data, measured in billion yuan and percentages, are obtained from the China Financial Statistics Yearbook.

(2) Insurance Density

This paper measures the degree of insurance coverage using Insurance Density, defined as the annual premium income of a region divided by its resident population, represented in Yuan/person. For robustness testing, alternative measures such as Insurance Penetration are considered, including Premium Income Percentage of GDP, Premium, and Compensation, sourced from the China Financial Statistics Yearbook.

(3) Economic Growth (Average GDP)

In this paper, Average GDP per capita has been chosen as a measure of the variable of economic growth in Yuan per person, which indicates the total value of goods and services created by the average resident of the region in a given period and can be used as one of the indicators of economic growth. This data is obtained from the National Statistical Office.

3.2.4 control variable

This paper uses Income, Average Sales, Average Patent, Public Service, Tertiary, Education, and Unemployment as control variables in the model. are added to the model as control variables.

This paper analyses the descriptive statistics of the relevant variables, as shown in the table below. From the perspective of the innovation and entrepreneurship index, the average value is 78.27, and the upper and lower limits of the maximum value are 99.9 and 21.96, respectively; the level of innovation and entrepreneurship varies in different regions, but more than half of the provinces of this index is in the middle and upper levels, resulting in a relatively optimistic national average value. In terms of the development level of digital inclusive finance, the average value is 202.3, and the upper and lower limits of the maximum value are 410.3 and 16.22, with a large range of data fluctuations and volatility.

Table 2 Descriptive statistics

	(1)	(2)	(3)	(4)	(5)
variant	N	mean	sd	min	max
FinanceIndex	279	202.30	91.65	16.22	410.30
InnovationIndex	279	78.27	16.21	21.96	99.90
loan1	279	1,014.00	1,006.00	6.71	5,063.00
loan2	279	31,233.00	26,998.00	409.10	167,995.00
BLR	279	1.58	1.08	0.20	8.70
BadLoan	279	377.80	418.1	3.50	2,528.00
InsuranceDensity	279	1,933	1,471	253	9,640
InsurancePenetration	279	3.30	1.18	0.03	7.39
compensation	279	260.80	219.90	3.34	1,061
premium	279	806.10	724.30	7.60	4,112
averageGDP	279	51,287.00	25,668.00	16,024.00	161,776.00
Income	279	22,202.00	10,562.00	7,510.00	69,442.00
consume	279	16,012.00	7,028.00	5,063.00	45,605.00
sales	279	9,587.00	8,317.00	219.00	42,664.00
AverageSales	279	4.38	3.80	0.10	19.48
patent	279	8,530.00	14,973.00	6.00	121,320.00
AveragePatent	279	3.90	6.84	0.00	55.40
RDinvest	279	84,340.00	117,009.00	22.00	642,490.00
PublicService	279	441.90	269.20	51.96	1,855.00
tertiary	279	11,425.00	10,328.00	346.10	60,268.00
education	279	8.67e+06	5.50e+06	807,466.00	3.716e+07
unemployment	279	6.93	7.39	0.00	34.23

4. Analysis of empirical results

4.1 Direct effects of digital inclusive finance for innovation and entrepreneurship

In the following, we first empirically test the direct impact effect of the digital financial inclusion index on the innovation and entrepreneurship index from two perspectives: the full sample and sub-region, to explore whether digital financial inclusion has an impact on the entrepreneurship index or not, the direction of the impact and the degree of the impact. When estimating by sub-region, spatial heterogeneity is tested from the perspective of East, Central and West.

4.1.1 Full sample effects test

Since this paper considers that the variance of the dependent variable changes within the range of values of the independent variable, the model obtained by ordinary least squares estimation under heteroskedasticity robustness was first tried as shown in column (1), and a random effects model was used. However, the regression coefficients do not pass the significance test and are in the opposite direction to the expected direction, so it is contrary to the theoretical assumptions and the actual situation.

Based on (1) this paper adds an individual fixed effects model as shown in column (2), which regards each individual with its specific invariant characteristics as an individual intercept term, controls the influence of individual heterogeneous fixed effects, and pays more attention to the direct effect of the core explanatory variable, the digital financial inclusion index. At this point, the overall F-value of the model passes the significance test, and the marginal impact coefficient of the digital financial inclusion index on the entrepreneurship index is also significant at the 1% significance level and is 0.109, passing hypothesis 1 of this paper. When other variables are controlled unchanged, for every one-unit increase in the digital financial inclusion index, the regional innovation and entrepreneurship index will be affected by it and rise by 0.109 units. influence to rise by 0.109 units. The R-squared of the model is 87.4%, and the model fits well.

Overall, promoting digital inclusive finance effectively encourages residents to innovate and start businesses. With its expanding reach and digitization, more residents access services like payment, credit, insurance, deposits, and investment, enhancing the financial environment for entrepreneurs. This broadens investment options and lowers risks, fostering innovation and entrepreneurship. Here's a summary of our services for entrepreneurs.

This paper also attempts to include estimates (3) that are heteroskedasticity robust to (2) and estimates (4) under cluster standard errors, with little difference in results compared to (2).

Table 3 Tests of the direct effect mechanism under random effects and individual fixed effects at the full sample size

variant	(1) OLS	(2) FE1	(3) FE2	(4) FE3
FinanceIndex	-0.004 (-0.47)	0.109*** (12.94)	0.109*** (8.53)	0.109*** (8.53)
Income	0.001*** (6.46)	-0.000 (-1.05)	-0.000 (-1.05)	-0.000 (-1.05)
AverageSales	1.574*** (3.63)	0.435 (0.75)	0.435 (0.78)	0.435 (0.78)
AveragePatent	-0.375 (-1.39)	-0.019 (-0.14)	-0.019 (-0.13)	-0.019 (-0.13)
PublicService	0.011 (1.18)	0.004 (0.85)	0.004 (0.76)	0.004 (0.76)
tertiary	-0.002*** (-3.52)	-0.001*** (-3.68)	-0.001*** (-4.50)	-0.001*** (-4.50)
education	0.000*** (5.98)	0.000 (1.24)	0.000 (0.93)	0.000 (0.93)
unemployment	0.263*** (3.19)	0.038 (0.35)	0.038 (0.39)	0.038 (0.39)
Constant	37.429*** (9.56)	63.899*** (28.66)	63.899*** (30.81)	63.899*** (30.81)
Observations	279	279	279	279
R-squared	0.756	0.874	0.874	0.874

FE	NO	YES	YES	YES
robust	YES	NO	YES	NO
cluster SE	NO	NO	NO	YES
Number of province_id	31	31	31	31

4.1.2 Sub-area effects test

Considering the regional heterogeneity in both the level of regional innovation and entrepreneurship and the level of digital financial inclusion development, the level of digital financial inclusion development in the eastern coastal region is significantly higher than that in the central and western regions, and the rate of digital financial inclusion development varies from region to region. In this paper, the sample is divided into three groups of east, central and west¹, and the estimation results in the following table are obtained.

Table 4 Tests for regional heterogeneity

variant	(1) EAST	(2) CENTRAL	(3) WEST
FinanceIndex	0.083*** (6.60)	0.015 (0.83)	0.115*** (5.59)
Observations	99	72	108
R-squared	0.852	0.949	0.899
Number of province_id	11	8	12

For the eastern region, a 1 unit rise in the digital financial inclusion index boosts the innovation and entrepreneurship index by 0.083 units, with significance at the 1% level. In the western region, each unit increase in the financial inclusion index results in a 0.115 unit rise in the innovation and entrepreneurship index, also significant at the 1% level. This suggests digital financial inclusion significantly influences innovation and entrepreneurship across both regions, with broader adoption and digitization enhancing residents' innovation and entrepreneurial activities.

Conversely, in the central region, the digital financial inclusion index's effect on the innovation and entrepreneurship index is minimal (0.015) and statistically insignificant, indicating a lesser impact of digital financial inclusion on innovation and entrepreneurship compared to the eastern and western regions.

4.2 Robustness tests

To enhance the conclusions and model reliability, this paper conducts robustness tests. Firstly, a fixed-effects panel regression is performed by trimming extreme values from the dataset, retaining only values within the 1st and 99th percentiles, and replacing outliers with boundary values. Column (1) displays the regression outcomes after this tail-trimming process. Despite the adjustments, the direct effect of digital financial inclusion on the innovation and entrepreneurship index remains notably positive, with a coefficient of 0.104 at the 1% significance level. Both statistical and economic significance affirm that digital financial inclusion positively influences regional innovation and entrepreneurship.

Furthermore, alternative sample sets are analyzed to assess financial inclusion's impact on innovation and entrepreneurship. Column (2) presents regression results after excluding municipal data from the 31 provinces, focusing solely on autonomous regions and provinces. This reduction in sample size aims to reaffirm the consistency and robustness of the findings. The results demonstrate a significant and stable marginal impact of the digital financial inclusion index on innovation and

¹ The eastern part here refers to the 11 provinces (cities) of Liaoning, Beijing, Tianjin, Hebei, Shandong, Jiangsu, Shanghai, Zhejiang, Fujian, Guangdong, and Hainan; the central region includes the 8 provinces of Heilongjiang, Jilin, Shanxi, Henan, Anhui, Hubei, Hunan, and Jiangxi; and the western region includes the 12 provinces (cities) of Xinjiang, Inner Mongolia, Gansu, Qinghai, Ningxia, Tibet, Shaanxi, Chongqing, Sichuan, Guizhou, Yunnan, and Guangxi, Autonomous Region).

entrepreneurship within provincial and autonomous regions, with a coefficient of 0.089 at the 1% level. This underscores that increased financial inclusion fosters positive and enduring effects on innovation and entrepreneurship.

The model and conclusions pass robustness tests, showing resilience to data deviations and estimation biases. This prevents sensitivity to distortion, ensuring reliable results. The direct positive impact of financial inclusion on innovation and entrepreneurship is reaffirmed.

Table 5 Robustness test

variant	(1) RT1	(2) RT2
FinanceIndex	0.104*** (12.13)	0.089*** (8.94)
Observations	279	243
R-squared	0.875	0.889
Number of province_id	31	27

4.3 Indirect effects of digital financial inclusion for innovation and entrepreneurship

4.3.1 Credit scale promotion effect

We assess if digital inclusive finance boosts innovation and entrepreneurship by expanding credit availability. Employing a fixed-effect model, we introduce credit scale as a mediating variable alongside the core digital financial inclusion index (X1), with additional control variables. Non-performing loan balances from commercial banks are utilized as an inverse measure of credit scale, denoted as X2, and incorporated into the base model for panel regression within the fixed-effect framework.

Using loan balance as a measure of credit size (column 1, Table 6), all coefficients are significant at the 1% level, yet unexpectedly negative, suggesting potential issues with data representativeness and completeness. Specifically, employing Bank of Communications' loan balance alone fails to capture the overall regional credit scale accurately, resulting in an unexpected coefficient for cross term X1. Although this finding doesn't necessarily refute hypothesis 2, it underscores the need for more comprehensive and representative data to validate further.

Alternatively, utilizing non-performing loan balances of commercial banks as an inverse measure of credit size (column 2, Table 6), cross term (X2) coefficients pass the 1% significance test, aligning with the expectation that higher non-performing loan balances mitigate financial inclusion's impact on entrepreneurship. In regions with smaller NPL balances, the level of digital financial inclusion significantly influences entrepreneurship, possibly due to lower risk perceptions prompting increased credit and financial support from commercial banks. Moreover, mature financial inclusion levels in such regions offer tailored financial instruments, promoting entrepreneurial success and growth. For the problem that the sign of the regression coefficients of the bad loan balance variable BAD LOAN in column (2) does not match the actual situation, it is due to the duplication of information explained with the cross terms, so there is a case of multicollinearity, which leads to the coefficients having positive and negative signs contrary to expectations.

To sum up, the results validate Hypothesis 2: The level of inclusive financial development will further promote the level of innovation and entrepreneurship by increasing the availability of credit. In particular, the change of inclusive financial development on the credit scale is mainly reflected in the quality of credit in the region through the reduction of non-performing loan balances, allowing entrepreneurs to access higher-quality loan funds, and motivating entrepreneurs' confidence in starting their businesses.

Table 6 Indirect effects test

variant	(1) loan1	(2) bad loan	(3) insurance	(4) GDP
FinanceIndex	0.095*** (11.12)	0.102*** (12.03)	0.083*** (9.98)	0.095*** (12.43)

loan1	0.009*** (3.04)			
X1	-0.000*** (-6.61)			
BadLoan		0.016*** (3.55)		
X2		-0.000*** (-3.19)		
InsuranceDensity			0.007*** (8.52)	
Y1			-0.000*** (-7.74)	
averageGDP				0.001*** (6.00)
Z				-0.000*** (-9.01)
Constant	53.488*** (17.45)	59.907*** (22.37)	47.836*** (15.17)	30.267*** (7.04)
Observations	279	279	279	279
R-squared	0.893	0.881	0.905	0.906
Number of province_id	31	31	31	31

4.3.2 Insurance coverage protection effects

To further examine if digital financial inclusion boosts innovation and entrepreneurship by increasing insurance coverage and mitigating risk for residents, we employ a fixed-effect model. We augment the base model with regional insurance density as a mediating variable and introduce the cross term (Y1) representing the product of insurance density and the digital financial inclusion index. Empirical results are presented in Table 6, column (3).

The regression coefficients of the digital financial inclusion index, insurance density, and the cross term are all significant at the 1% significance level, but the sign of the coefficient of the cross term is opposite to what is expected, which is inconsistent with Hypothesis 3. The direct positive effect of digital financial inclusion on innovation and entrepreneurship is much larger than the indirect negative effect on innovation and entrepreneurship through the intermediary mechanism of insurance coverage.

According to the empirical results, an increase in insurance density weakens the promotional effect of financial inclusion on innovative entrepreneurship. This may imply that the likelihood of entrepreneurship and entrepreneurial success may be inhibited to some extent when the level of financial inclusion is high but the insurance density is low. The conjecture may be that there exists a significant substitution effect between other services of financial inclusion and traditional insurance services. This is because as insurance density increases, entrepreneurs are more inclined to seek insurance protection when facing risks, which reduces their demand and reliance on financial inclusion and eliminates the need to invest in other asset portfolios for risk management, thus weakening the impact of financial inclusion on entrepreneurship. On the other hand, there may also be a negative interaction effect between financial inclusion and insurance density. When the level of financial inclusion is high, the impact of increased insurance density on entrepreneurship may gradually weaken or even become negative. High levels of financial inclusion already provide relatively adequate financial support and protection, and further increases in insurance density may have diminishing benefits and may discourage entrepreneurs from making entrepreneurial decisions.

In summary, this paper argues that there is a substitution effect between the level of insurance coverage and the level of inclusive financial development, and that the more developed the level of insurance coverage is, the weaker the promotional effect of inclusive financial development on innovation and entrepreneurship is, contrary to Hypothesis 3 proposed in this paper.

4.3.3 Economic growth-enhancing effects

Finally, hypothesis 4 is tested, i.e., whether digital financial inclusion further promotes the overall level of innovation and entrepreneurship in a region through promoting economic growth. The GDP per capita of a region is added as a mediating variable to the original model, as well as its cross term (named Z) with the digital financial inclusion index, and the results are shown in column (4) of Table 6.

The regression coefficients of the digital inclusion index, the level of economic growth, and the cross term are all significant at the 1% significance level, but the sign of the coefficient of the cross term is the opposite of what is expected, which is inconsistent with hypothesis 4. The consequences and impacts of economic growth may work inversely on the level of entrepreneurship through other aspects. For example, high levels of GDP per capita may have the consequence of high employee wage levels, leading entrepreneurs to be more inclined to be employed rather than self-employed, posting high wages for their employees. On the other hand, an increase in GDP per capita may also increase the competitiveness of social entrepreneurship, which may also lead entrepreneurs to abandon their reliance on the demand for capital brought about by inclusive finance and to abandon entrepreneurship.

In summary, hypothesis 4 is not tested, and the mediating path that digital financial inclusion can promote innovation and entrepreneurship among residents by promoting the level of economic development needs to be further verified and improved.

5. Research findings and policy recommendations

Based on existing studies, this paper uses annual panel data from 2011-2019 to study the impact effect of the level of digital inclusive finance development on residents' innovation and entrepreneurship in different regions from the national level and in the East, Central and West regions in two dimensions respectively, and the results show that the level of digital inclusive finance development indeed positively affects the level of innovation and entrepreneurship of the residents, and this impact effect is significant in the East and West regions.

The results of the intermediary mechanism analysis show that the level of inclusive financial development will further promote the level of innovation and entrepreneurship by improving the availability of credit, and the change in credit scale is mainly reflected in the improvement of the quality and availability of credit in the region by reducing the balance of non-performing loans. Second, there is a substitution effect between the degree of insurance coverage and the level of inclusive financial development, and the more developed the degree of insurance coverage, the weaker the impact of inclusive financial development on the promotion effect of innovation and entrepreneurship.

In response to these conclusions, the paper makes the following targeted recommendations:

Firstly, improve loan quality and quantity to provide entrepreneurs with high-quality capital protection. Banks should strengthen risk prevention and control, adhere to prudent management, and formulate a credit review process to reduce borrowing thresholds and prevent bad debt.

Then, the CBI should innovate and serve small entrepreneurs by deepening the financial inclusion mechanism and comparing regulatory evaluation indicators. Banks and insurance institutions should improve data governance and strengthen quality control of key indicators.

Lastly, reduce regional resource disparities by integrating resources across regions. High-quality talents, core technologies, financial support, and relevant policies are essential for entrepreneurship. Inclusive finance can address the central region's shortcomings, combining it with innovation and cross-regional cooperation to alleviate unbalanced development.

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