Proceedings of the 10th International Conference on Economic Management and Green Development
DOI: 10.54254/2754-1169/2026.LD38086

Research on the Inclusive Finance Effect of Digital Renminbi

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Abstract. Amid the ongoing wave of the digital and intelligent technological revolution, central bank digital currency has become an important vehicle to reshape the financial service system. As China's self-developed central bank digital currency, digital renminbi provides a new tool to break through the bottlenecks in the development of traditional inclusive finance. Relying on its legal tender attributes and advantages of digital technologies, digital renminbi effectively expands the reach of financial services and serves as a key measure to improve the quality and efficiency of inclusive finance. This paper systematically discusses the theoretical mechanism through which digital renminbi empowers inclusive finance, and conducts empirical tests using the panel data fixed-effects model, with the outstanding loan balance of inclusive small and micro enterprises as the explained variable. The study shows that the launch of digital renminbi pilots exerts a significant positive driving effect on regional inclusive finance development. In addition, regional economic development level, fiscal expenditure, urbanization rate and internet penetration rate all significantly promote the expansion of inclusive credit; by contrast, deepening population aging and rising inflation level generate negative restraining effects. This paper proposes to steadily expand digital renminbi pilots and promote the application of smart contracts, implement differentiated downward outreach strategies adapted to local conditions, strengthen digital infrastructure and carry out age-friendly transformation, so as to offer empirical evidence for the construction of China's inclusive finance ecosystem.

Keywords: digital renminbi, inclusive finance, loans for small and micro enterprises, fixed-effects model, information asymmetry

1. Introduction

Digital renminbi (e-CNY) is the digital form of legal tender issued by the People's Bank of China. Its core concept originates from forward-looking exploration into the digitalisation of traditional currency forms, aiming to meet payment demands in the era of digital economy. Unlike decentralised cryptocurrencies such as Bitcoin, digital renminbi is legally equivalent to physical renminbi and possesses legal tender status.

China launched research and development of its central bank digital currency (e-CNY) in 2014, after which the development of digital renminbi entered a fast track. In 2016, the Digital Currency Institute of the People's Bank of China was formally established and built the first-generation prototype system. Later, under the overall coordination of the State Council, the People's Bank of

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DOI: 10.54254/2754-1169/2026.LD38086

China partnered with major commercial institutions to launch research trials in 2017. Starting from 2018, digital renminbi transitioned from internal closed testing to orderly pilots across multiple scenarios. The release of the *White Paper on Research and Development Progress of China's Digital Renminbi* [1] in 2021 confirmed the central bank's core role in quota adjustment and supervision. After 2023, system upgrading became the primary task. Statistics show that by the end of 2025, the number of opened digital renminbi wallets reached 230 million, with cumulative settlement volume exceeding 19.5 trillion yuan. Following the full implementation of the new-generation operation mechanism on New Year's Day 2026, the ecosystem of digital renminbi has stepped into a new era of mature application.

At present, digital renminbi has formed a multi-level and full-coverage application landscape in China. In practical application, digital renminbi has built a comprehensive application matrix covering retail consumption, government services and corporate cross-border businesses. First, in the field of small-value retail, through deep integration with mainstream platforms including JD.com and Alibaba as well as offline supermarkets, digital renminbi achieves efficient real-time settlement. Its unique "offline payment" technology breaks constraints imposed by network conditions and greatly expands the reach of payment services. Second, within government affairs and livelihood systems, digital renminbi serves as a powerful tool to improve governance efficiency, and is widely adopted in scenarios such as targeted distribution of consumption vouchers, accurate disbursement of fiscal subsidies and convenient tax payment. Besides, corporate and cross-border transactions represent new growth drivers: enterprises use digital renminbi for payroll disbursement and social insurance contribution to realise efficient capital flow management. In global payment, relying on key projects such as the multiple central bank digital currency bridge (mBridge), the strategic value of digital renminbi in simplifying cross-border settlement procedures, cutting exchange costs and accelerating settlement speed is being unlocked at an accelerated pace.

Multi-scenario applications of digital renminbi represent not merely an upgrade of payment instruments, but also a core engine driving high-quality development of inclusive finance. Inclusive finance strives to provide fair and low-cost financial services for long-tail groups. With its zero-fee design, digital renminbi substantially cuts capital circulation costs and lowers entry barriers to basic financial services. Meanwhile, its dual offline payment function effectively overcomes physical barriers caused by limited network access in remote areas and markedly improves the spatial accessibility of financial services. More importantly, under the controllable anonymity framework, digital renminbi converts fragmented transactions previously excluded from traditional financial systems into tamper-proof "digital footprints". This substantially mitigates information asymmetry between long-tail groups and financial institutions, grants groups without credit records opportunities to build credit assets, and supplies credible data support for targeted services for small and micro enterprises. It therefore empowers the development of the inclusive finance ecosystem comprehensively in both breadth and depth.

Against this backdrop, this study attempts to examine the relationship between digital renminbi and inclusive finance, and systematically sort out the theoretical mechanisms and transmission paths through which digital renminbi empowers inclusive finance. By constructing an empirical model, this paper thoroughly evaluates the actual boosting effect and heterogeneous characteristics brought by digital renminbi rollout on regional inclusive finance levels. It aims to provide solid empirical evidence for China to optimise the top-level design of digital currency and advance high-quality development of inclusive finance.

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2. Theoretical foundations of the inclusive finance effect of digital renminbi

2.1. Information asymmetry theory and credit discovery via "digital footprints"

The classic credit rationing theory [2] states that severe information asymmetry exists between banks and enterprises. To avoid adverse selection [3], financial institutions tend to raise interest rates or require collateral. This leaves long-tail groups lacking collateral and continuous credit histories subject to heavy credit constraints. A large body of recent research demonstrates that alternative data derived from digital payments can effectively mitigate such information asymmetry [4, 5].

For digital renminbi, its controllable anonymity framework preserves privacy while enabling digitised records of transaction chains. Research by domestic scholar Cao Huifang [6] shows that the promotion of digital renminbi helps break data silos among traditional financial institutions, converting high-frequency daily small-value payments of long-tail customers into tamper-proof "digital footprints". Such data accumulation backed by central bank credit provides a data foundation for financial institutions to adopt machine learning and other technologies for more accurate risk pricing [7]. By converting payment data into inputs for credit evaluation, digital renminbi substantially cuts information search costs for financial institutions, eases credit rationing at the micro level, and improves credit access for vulnerable groups.

2.2. Transaction cost theory and expansion of financial service boundaries

Transaction cost theory [8, 9] offers a micro perspective for understanding the geographic outreach of financial services. When expanding services to low-income groups or remote regions, traditional financial institutions face high fixed costs for branch construction, cash management and interbank settlement. Consequently, their service coverage is mostly limited to densely populated and economically developed areas. In this regard, multiple studies by the Bank for International Settlements [10] point out that the introduction of retail central bank digital currency (Retail CBDC) can markedly optimise the cost structure of basic payment systems.

The two-tier operation and zero-fee design of digital renminbi eliminates cumbersome interbank settlement procedures seen in conventional electronic payments and greatly reduces capital circulation costs [11]. In addition, its dual offline payment function lessens heavy reliance on network communication infrastructure in remote regions. The sharp reduction in marginal transaction and outreach costs allows financial institutions to extend business to lower-tier markets in an economically viable manner. Lowered entry thresholds for basic financial accounts not only raises payment inclusiveness, but also builds low-cost service channels for long-tail customers to access formal credit support in subsequent stages.

2.3. Public goods theory and inclusiveness of financial infrastructure

Modern legal tender functions not merely as a medium of exchange, but also as fundamental financial infrastructure sustaining economic operations. From the public goods perspective, Chiu and Hofmann [12] argue that in the digital era, payment instruments entirely dominated by the private sector inevitably carry risks of data monopoly and exclusive competition. As a direct extension of state credit, central bank digital currency features the quasi-public-good attributes of non-excludability and non-rivalry.

The legal tender status of digital renminbi guarantees its broad user base. This institutional supply at the national level effectively fills service gaps in long-tail markets left by commercial institutions

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driven by profit motives. Relevant IMF working papers [11] also stress that providing widely accessible legal digital currency with no usage barriers constitutes an important way to guarantee equal financial participation rights for the public in the digital economy. By supplying this basic financial public good, digital renminbi establishes the institutional cornerstone for inclusive finance development and provides underlying infrastructure safeguards for fair and inclusive allocation of credit resources.

3. Empirical analysis of the inclusive finance effect of digital renminbi

3.1. Research hypotheses

As a new type of financial infrastructure serving both as a payment instrument and an information carrier, digital renminbi exerts profound influences on inclusive finance mainly through two mechanisms: reducing transaction costs and mitigating information asymmetry.

Transaction Cost Reduction and Expansion of Service "Breadth": When traditional financial institutions extend services to remote or lower-tier markets, they often face high branch construction costs and frictions in interbank settlement. Relying on the two-tier operation and zero-fee design, digital renminbi removes complicated intermediate settlement links; its dual offline payment function further breaks physical constraints of basic network communication. This sharp drop in marginal supply costs enables financial institutions to extend service reach into long-tail markets in an economically feasible way. It creates low-threshold financial access for small and micro enterprises and low-income groups, thereby significantly broadening the coverage breadth of inclusive finance.

Mitigation of Information Asymmetry and Improvement of Service "Depth": Within the classic credit rationing framework, small and micro enterprises commonly encounter severe financing constraints due to insufficient collateral and missing credit records. Under the controllable anonymity framework, digital renminbi can convert fragmented, high-frequency transaction activities in lower-tier markets into credible and tamper-proof "digital footprints". Such alternative data endorsed by state credit greatly cuts the information search costs incurred by financial institutions in pre-loan due diligence and post-loan monitoring. It helps banks reshape risk pricing models, allowing credit resources to flow precisely to groups without conventional credit histories and effectively deepening the performance of inclusive finance.

Synthesising the above theoretical mechanisms, digital renminbi eliminates blind spots in physical infrastructure while reconstructing the underlying digital trust system. This dual empowerment is expected to greatly stimulate credit vitality in lower-tier markets and improve the fair allocation of credit resources.

Accordingly, this paper puts forward the following core research hypothesis: The implementation of digital renminbi pilots is expected to significantly raise the outstanding loan volume of inclusive small and micro enterprises in pilot regions.

3.2. Variable selection

3.2.1. Dependent variable and core explanatory variable

The dependent variable (Y) is set as inclusive small and micro enterprise loans. Under the classic credit rationing framework, small and micro enterprises often suffer from financing constraints due to the lack of sufficient collateral and continuous traditional credit records. The "digital footprints"

DOI: 10.54254/2754-1169/2026.LD38086

accumulated by digital renminbi can provide credible data support for financial institutions to deliver targeted services to small and micro enterprises. Therefore, this paper adopts the logarithm (or year-on-year growth rate) of the outstanding balance of inclusive small and micro enterprise loans in each region as the dependent variable.

The core explanatory variable (X) is defined as the policy impact variable of "digital renminbi". Following the principle combining time benchmark and spatial heterogeneity, it is constructed as a dummy variable: if a city launches the digital renminbi programme in a specific year, the value is assigned 1 for that year and all subsequent years; the value is assigned 0 for periods without programme rollout or before implementation.

3.2.2. Control variables

This paper introduces the following macroeconomic variables as control variables.

Aging degree: Based on the life-cycle theory, population aging generally imposes a negative restraining effect on the development of inclusive finance. When facing sophisticated digital financial products, elderly groups are highly vulnerable to the digital divide and tend to revert to cash transactions. The inclusion of this indicator not only controls the heterogeneity of population age structure, but also highlights the unique value of the age-friendly design of digital renminbi in bridging the digital divide in subsequent tests. This paper uses the proportion of population aged 65 and above in the total population to measure regional aging levels. Relevant data are mainly sourced from the *China Statistical Yearbook* of successive years.

Regional per capita GDP: In line with the demand-following hypothesis of financial development, per capita GDP reflects regional macroeconomic strength and household wealth accumulation. More economically developed regions show stronger demand for high-frequency payments, credit and wealth management. Hence, per capita GDP exerts a significant positive driving effect on the inclusive finance index. This paper adopts the logarithm of regional per capita GDP to measure this indicator. Relevant data are mainly obtained from the website of the National Bureau of Statistics.

Broadband internet penetration rate: According to the network externality theory, stable broadband internet access constitutes fundamental hardware support for traditional digital inclusive finance. This variable is introduced and controlled mainly to isolate the inclusive effect generated by conventional third-party electronic payment services such as WeChat Pay and Alipay, which heavily rely on network communication infrastructure. Unlike traditional electronic payment tools, digital renminbi features unique dual offline payment and hard wallet functions. Transactions and settlements can be completed even in regions with weak broadband coverage or no network access at all. Therefore, incorporating broadband internet penetration as a control variable can effectively remove the natural boosting effect of regional basic network infrastructure construction on inclusive finance. On this basis, if the core explanatory variable of digital renminbi remains significantly positive, it fully confirms that relying on underlying technologies such as dual offline payment, digital renminbi effectively fills gaps in financial services in regions with underdeveloped network infrastructure and delivers an independent policy effect that crosses the digital divide. This paper uses the ratio of broadband internet subscribers to permanent residents in each region, namely the number of broadband subscribers per hundred people, to represent this indicator. Relevant macro data are mainly derived from the *Communications Industry Statistical Bulletin* released by the Ministry of Industry and Information Technology.

Urbanisation level: Driven by spatial agglomeration effects, regions with high urbanisation levels feature dense population and commerce. Financial institutions bear low average fixed costs for

DOI: 10.54254/2754-1169/2026.LD38086

service outlets and can readily develop a sound financial ecosystem. Accordingly, urbanisation level naturally exerts a positive promotional effect on inclusive finance. This paper adopts the permanent resident urbanisation rate to measure this indicator. Relevant data are sourced from the website of the National Bureau of Statistics and Wind Financial Terminal.

CPI (Consumer Price Index): CPI reflects regional macro inflation. High inflation severely erodes the real purchasing power of middle- and low-income groups, strengthens their motive for precautionary savings, increases household financial vulnerability and pushes them out of risky wealth management markets. Meanwhile, sustained price hikes raise operating costs and compress profit margins for small and micro enterprises, which increases default risks faced by financial institutions and induces them to cut credit supply to lower-tier markets. Therefore, rising CPI generally impedes regional inclusive finance development by suppressing financial service demand (such as investment and wealth management) among long-tail groups and reducing the supply of inclusive credit from financial institutions. This paper uses the regional consumer price index (CPI, with the previous year set as 100) to measure this indicator. Data are mainly from successive volumes of the *China Statistical Yearbook*.

Fiscal expenditure: Within the macro-control framework, government fiscal transfer payments directly raise disposable income for middle- and low-income groups. Combined with smart contract technology linked to digital renminbi, efficient and targeted allocation of fiscal funds can effectively stimulate willingness among users in lower-tier markets to open and use digital wallets. The combination of the two is expected to generate a significant positive multiplier effect on inclusive finance. This paper uses the ratio of local general public budget expenditure to regional GDP to measure the intensity of local fiscal expenditure. Relevant data are obtained from successive *China Statistical Yearbook* and provincial and municipal statistical communiqués.

3.3. Empirical regression analysis

3.3.1. Variable description

To examine the impact of digital renminbi pilots on inclusive small and micro enterprise loans, this paper takes the logarithm of the outstanding balance of inclusive small and micro enterprise loans as the dependent variable, digital renminbi pilot as the core explanatory variable, and introduces a set of macroeconomic and social development indicators as control variables. The specific variable definitions, symbols, names and calculation methods are presented in Table 1.

Table 1. Variable definitions

Variable Category	Variable Symbol	Variable Name	Calculation and Description
Dependent variable	ln_loan	Inclusive small and micro enterprise loans	Natural logarithm of the outstanding balance of inclusive small and micro enterprise loans (in trillion yuan) to mitigate heteroskedasticity
Core explanatory variable	dcny	Dummy variable for digital renminbi pilot	Equals 1 in the pilot launch year and subsequent years; equals 0 in non-pilot years

DOI: 10.54254/2754-1169/2026.LD38086

Table 1. (continued)

Control variable	ln_fis	Local fiscal expenditure	Natural logarithm of local fiscal expenditure (in hundred billion yuan)
Control variable	urban	Urbanisation rate	Permanent resident urbanisation rate (%)
Control variable	old	Old-age dependency ratio	Dependency ratio of population aged above 65 (%)
Control variable	internet	Broadband penetration rate	Number of broadband subscribers per 100 residents
Control variable	cpi	Consumer price index	Previous year =100
Control variable	ln_gdp	Regional gross domestic product	Natural logarithm of regional GDP (in trillion yuan)

3.3.2. Descriptive statistics

Prior to regression analysis, this paper first conducts descriptive statistics for all core variables, and the results are shown in Table 2.

Table 2. Descriptive statistics of main variables

Variable	Observations	Mean	Std. Dev.	Min	Max
ln_loan	78	2.273	0.912	-0.087	3.655
dcny	78	0.833	0.375	0	1
ln_fis	78	4.236	0.685	2.982	5.202
urban	78	72.51	10.12	56.73	89.60
old	78	22.37	4.42	12.85	30.84
internet	78	45.27	7.32	30.87	60.32
cpi	78	101.02	0.91	99.70	102.70
ln_gdp	78	3.942	0.876	1.730	4.982

It can be seen from Table 2 that the value range and distribution characteristics of each variable are reasonably representative. Among them, the urbanisation rate (*urban*) has a relatively large standard deviation (10.12), with a substantial gap between its minimum value (56.73) and maximum value (89.60). This indicates strong heterogeneity in national spatial distribution and regional economic development across the sample, and different pilot cities are at distinct stages of urbanisation. In addition, the mean value of consumer price index (*cpi*) is 101.02, showing that the overall macro price level maintained a stable mild rise during the sample period, ruling out disturbances from drastic inflation on the credit market.

DOI: 10.54254/2754-1169/2026.LD38086

3.3.3. Regression model specification

To investigate the actual impact of digital renminbi on inclusive small and micro enterprise loans, this paper constructs the following baseline panel regression model and incorporates each control variable sequentially:

$$ln_loan_{it} = \beta_0 + \beta_1 dcny_{it} + \beta_2 ln_fis_{it} + \beta_3 urban_{it} + \beta_4 old_{it} + \beta_5 internet_{it}$$

$$+\beta_6 cpi_{it} + \beta_7 ln_gdp_{it} + \mu_i + \delta_t + \varepsilon_{it}$$

where i denotes region, t denotes year; the dependent variable $\ln_loan_{it}$ is inclusive small and micro enterprise loans; the core explanatory variable $dcny_{it}$ represents digital renminbi pilot; $\ln_fis_{it}$ is local fiscal expenditure; $urban_{it}$ is urbanisation rate; old_{it} is old-age dependency ratio; $internet_{it}$ is broadband penetration rate; cpi_{it} is consumer price index; $\ln_gdp_{it}$ is regional gross domestic product; μ_i stands for province/individual fixed effects, which capture time-invariant regional characteristics; δ_t represents year fixed effects to absorb shocks from macroeconomic cycles; ε_{it} is the random disturbance term.

This paper adopts pooled OLS univariate model (Model 1), pooled OLS model with full control variables (Model 2), individual fixed effects model (Model 3) and two-way fixed effects baseline model (Model 4) for stepwise regression in sequence to verify the robustness of the results.

3.3.4. Interpretation of regression results

Detailed regression results are reported in Table 3.

Table 3. Regression results

Variable	Model 1 (Univariate)	Model 2 (Full Controls)	Model 3 (Individual FE)	Model 4 (Two-way FE)
dcny	0.542*** (0.124)	0.126** (0.058)	0.087** (0.039)	0.092*** (0.031)
ln_fis	-	0.214*** (0.063)	0.158** (0.071)	0.103* (0.056)
urban	-	0.031*** (0.008)	0.024** (0.011)	0.019* (0.010)
old	-	-0.027** (0.012)	-0.020* (0.011)	-0.022** (0.010)
internet	-	0.018** (0.008)	0.015* (0.008)	0.012* (0.007)
cpi	-	-0.089** (0.037)	-0.076** (0.034)	-0.068* (0.036)
ln_gdp	-	0.623*** (0.072)	0.541*** (0.085)	0.487*** (0.079)
Constant	1.821*** (0.108)	-5.124*** (1.247)	-3.872*** (1.125)	-3.105** (1.326)
Province fixed effects	No	No	Yes	Yes
Year fixed effects	No	No	No	Yes
Observations	78	78	78	78
R^2	0.235	0.921	0.964	0.976

Notes: Standard errors are reported in parentheses; ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

DOI: 10.54254/2754-1169/2026.LD38086

First, the core explanatory variable and all control variables pass significance tests across all four models. Such highly consistent significance under alternative model specifications not only demonstrates the soundness and rationality of the control variable selection, but also fundamentally verifies the core theoretical hypothesis proposed above from an empirical perspective. It confirms a robust causal relationship between each variable and the development of inclusive finance.

To further eliminate confounding time-invariant regional heterogeneity, this paper focuses on Model 3 (individual fixed effects model). Under this specification, the estimated coefficients of each variable carry clear and economically intuitive interpretations:

Digital renminbi pilot (dcny)

Its estimated coefficient equals 0.087 and is significantly positive at the 5% level. This means that holding other macroeconomic and socioeconomic variables constant, the launch of digital renminbi pilots raises the outstanding balance of local inclusive small and micro enterprise loans by 8.7%. This result strongly suggests that digital renminbi exerts a significant positive effect on inclusive small and micro enterprise loans, namely the development of inclusive finance. It fully echoes the preceding theoretical deduction that digital renminbi promotes financial inclusion by reducing transaction frictions and reaching long-tail groups, and fundamentally validates the core conclusion of this paper.

Regional gross domestic product (ln_gdp)

Its estimated coefficient is 0.541 and highly significantly positive at the 1% level. The result shows that a 1% increase in regional gross output (economic development level) raises inclusive small and micro enterprise loans by 0.541%. Consistent with the demand-following hypothesis of financial development outlined earlier, stronger macroeconomic performance and accumulated regional wealth endogenously generate greater demand for high-frequency payments and credit financing, serving as the core material foundation driving the expansion of inclusive finance.

Local fiscal expenditure (ln_fis)

Its estimated coefficient is 0.158 and significantly positive at the 5% level. A 1% expansion in local fiscal expenditure increases the outstanding balance of inclusive small and micro loans by 0.158%. This finding confirms the positive effect of fiscal policy on the real economy involving enterprises. Fiscal support from governments not only improves the business environment for small and micro enterprises, but also mitigates banks' risk aversion through government credit enhancement mechanisms, thereby effectively boosting credit supply to small and micro businesses.

Urbanisation rate (urban)

Its estimated coefficient is 0.024 and significantly positive at the 5% level. A one-percentage-point rise in the permanent resident urbanisation rate increases the balance of inclusive small and micro loans by 2.4%. This aligns with the foregoing discussion. As urbanisation proceeds, population and secondary and tertiary industries agglomerate in cities. Optimised spatial distribution creates denser demand for financial services and cuts the physical costs for financial institutions to open branches and extend services.

Control variable: Broadband penetration rate (internet)

Its estimated coefficient is 0.015 and significantly positive at the 10% level. Each additional broadband subscriber per one hundred residents lifts the balance of inclusive loans by 1.5%. The positive coefficient supports the fundamental role of digital infrastructure as hardware backing for traditional digital inclusive finance. Wider network access partially mitigates information asymmetry and naturally facilitates credit outreach to lower-tier markets.

Control variable: Old-age dependency ratio (old)

DOI: 10.54254/2754-1169/2026.LD38086

Its estimated coefficient is -0.020 and significantly negative at the 10% level. A one-percentage-point increase in the old-age dependency ratio reduces the balance of inclusive small and micro loans by 2.0%. This negative effect confirms the earlier concerns regarding population structure and the digital divide. Rising ageing is usually accompanied by weaker regional investment willingness. Elderly groups' relative reluctance to adopt digital financial products tends to induce financial repression and dampens the expansion of small and micro loans.

Control variable: Consumer price index (cpi)

Its estimated coefficient is -0.076 and significantly negative at the 5% level. Each one-unit rise in the price index (with the previous year set as 100) reduces the balance of inclusive small and micro loans by 7.6%. This indicates mounting macro inflation suppresses real credit expansion. A possible explanation is that higher CPI triggers market expectations of monetary policy tightening. Meanwhile, rising prices directly push up operating costs for small and micro enterprises and weaken their willingness to borrow.

4. Policy recommendations

First, steadily expand the scope of digital renminbi pilots to release the positive innovative effects of inclusive finance. The empirical results show that the implementation of digital renminbi pilots has significantly increased the outstanding balance of inclusive small and micro enterprise loans by 8.7%. Therefore, the top-level design should continue to steadily expand the coverage of pilot cities and application scenarios for digital renminbi. Leveraging the programmable technical advantages of digital renminbi, commercial banks should be encouraged to embed smart contract technology into credit products for small and micro enterprises, so as to realize the targeted and precise allocation of credit funds and full-process automatic closed-loop management. This can not only effectively reduce banks' costs of penetrating post-loan supervision, but also fundamentally alleviate the long-standing problems of difficult and expensive financing for small and micro enterprises, and amplify the inclusive effects of e-CNY.

Second, implement spatially differentiated policies tailored to local conditions to bridge the financial divide in the process of regional urbanization. Descriptive statistics reveal significant spatial heterogeneity in urbanization rates across regions in China, and the empirical results indicate that every one-percentage-point increase in the urbanization rate can significantly boost the growth of inclusive loans by 2.4%. Accordingly, policy formulation must adhere to the principle of adapting measures to local conditions. Mature pilot regions with high urbanization rates and prominent spatial agglomeration effects should focus on refining the operation of digital renminbi in high-frequency commercial scenarios. In non-pilot or newly launched pilot regions with low urbanization rates and relatively backward economic development, governments need to tilt more public resources. The popularisation of digital renminbi in grassroots markets can offset the disadvantage of insufficient physical bank outlets, and the gradual optimisation of spatial layout will drive balanced development of inclusive finance.

Third, strengthen the construction of digital network infrastructure and unlock the synergistic dividends of traditional infrastructure and digital currency. The significantly positive estimated coefficient of broadband penetration rate (*internet*) equals 0.015, which verifies that network infrastructure serves as fine hardware capillaries for the implementation of digital inclusive finance. Governments should further increase fiscal investment in new infrastructure such as 5G base stations and broadband networks in underdeveloped and rural areas. By raising network penetration, information asymmetry faced by long-tail groups can be mitigated, and a solid "digital foundation" can be built for the smooth circulation of digital renminbi and downward credit outreach. In this

DOI: 10.54254/2754-1169/2026.LD38086

way, coordinated progress can be achieved between the construction of physical infrastructure and the issuance of digital legal tender.

Fourth, actively cope with the demographic shock of population ageing and cross the "digital dividend barrier" in the supply of inclusive credit. Regression results show that the old-age dependency ratio (*old*) exerts a significant negative restraining effect on inclusive loans, with a coefficient of -0.020. This warns policymakers that the "digital divide" brought by population ageing is hindering credit expansion. When promoting digital renminbi and relevant credit products, financial institutions must carry out thorough age-friendly transformation, simplify operation interfaces and lower the technical barriers of digital services. Meanwhile, exclusive green financing channels via digital renminbi should be opened for small and micro enterprises within the silver economy and elderly care industrial chains, turning the negative shock of demographic structure into development opportunities for industrial transformation.

Fifth, closely monitor macro price and fiscal fluctuations and improve the multi-dimensional countercyclical adjustment mechanism. Empirical evidence suggests that local fiscal expenditure (ln_fis) and consumer price index (*cpi*) impose positive driving effects (regression coefficient = 0.158) and negative restraining effects (regression coefficient = -0.076) on inclusive loans respectively. Therefore, the promotion of digital renminbi cannot proceed alone; it must coordinate closely with macroeconomic policies. Faced with macro shocks such as rising prices and climbing operating costs of small and micro enterprises, local governments should take proactive actions. When issuing special enterprise subsidies and industrial support funds, governments should prioritise the direct and targeted disbursement in the form of digital renminbi. Through deep coordination between proactive fiscal policies and digital renminbi tools, the countercyclical adjustment function can be effectively exerted to deliver stable liquidity expectations for small and micro enterprises.

5. Conclusion

Taking the digital renminbi pilots as a quasi-natural experiment, this paper first interprets the theoretical mechanism whereby digital renminbi expands both the breadth and depth of financial services. Drawing on the information asymmetry theory, transaction cost theory and public goods theory, digital renminbi accumulates credible "digital footprints" under its controllable anonymity framework and cuts transaction costs through the two-tier operation and zero-fee design. On this basis, this paper constructs a panel fixed-effects model for empirical tests. The outstanding balance of inclusive small and micro enterprise loans is adopted as the dependent variable, and the dummy variable of digital renminbi pilots serves as the core explanatory variable. A set of control variables are also incorporated, including regional economic development level, local fiscal expenditure, urbanisation rate, broadband penetration rate, ageing degree and consumer price index. The study finds that the launch of digital renminbi pilots exerts a significant positive driving effect on regional inclusive finance development. After controlling for other variables, the outstanding balance of inclusive small and micro enterprise loans in pilot regions rises by approximately 8.7% on average. This result remains robust under multiple model specifications including pooled regression, individual fixed effects and two-way fixed effects, which verifies the theoretical judgement that digital renminbi empowers inclusive finance by reducing transaction frictions and mitigating information asymmetry.

In terms of control variables, regional economic development level, local fiscal expenditure, urbanisation rate and broadband penetration rate all significantly promote the expansion of inclusive credit. It indicates that economic foundation, fiscal support, spatial agglomeration and digital

DOI: 10.54254/2754-1169/2026.LD38086

infrastructure jointly form supporting conditions for inclusive finance development. By contrast, population ageing and inflation level impose significant restraining effects on the growth of inclusive small and micro enterprise loans. This reflects that the digital divide and macro price fluctuations reduce the accessibility of financial services for long-tail groups and small and micro enterprises. The full play of digital renminbi's inclusive effect is still constrained by multiple factors such as demographic structure, regional disparities and infrastructure conditions.

Accordingly, this paper proposes coordinated efforts in the following aspects: steadily expand digital renminbi pilots and promote smart contract applications to realise targeted fund disbursement and closed-loop management of small and micro credit; carry out differentiated outreach strategies adapted to local conditions and scale up promotion in regions with low urbanisation and insufficient financial outlets; strengthen the construction of new infrastructure such as 5G and broadband in rural and underdeveloped areas to consolidate the digital foundation for digital currency circulation; implement age-friendly upgrades for digital renminbi products and enhance its countercyclical coordination with proactive fiscal policies, so as to form institutional synergy for digital renminbi to drive high-quality development of inclusive finance.

This paper has certain limitations. Restricted by the number of pilot samples and the research period, the external validity of empirical conclusions needs further verification with longer time horizons and larger samples. The micro transmission mechanism of digital renminbi's inclusive effect at the firm and household levels also needs to be identified with micro survey data. As the operating mechanism of digital renminbi keeps maturing and its application scenarios keep expanding, its institutional value in bridging the digital divide and advancing financial fairness is expected to be further unlocked, which constitutes a key direction for future research.

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